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SCIENCE

23 May 1958

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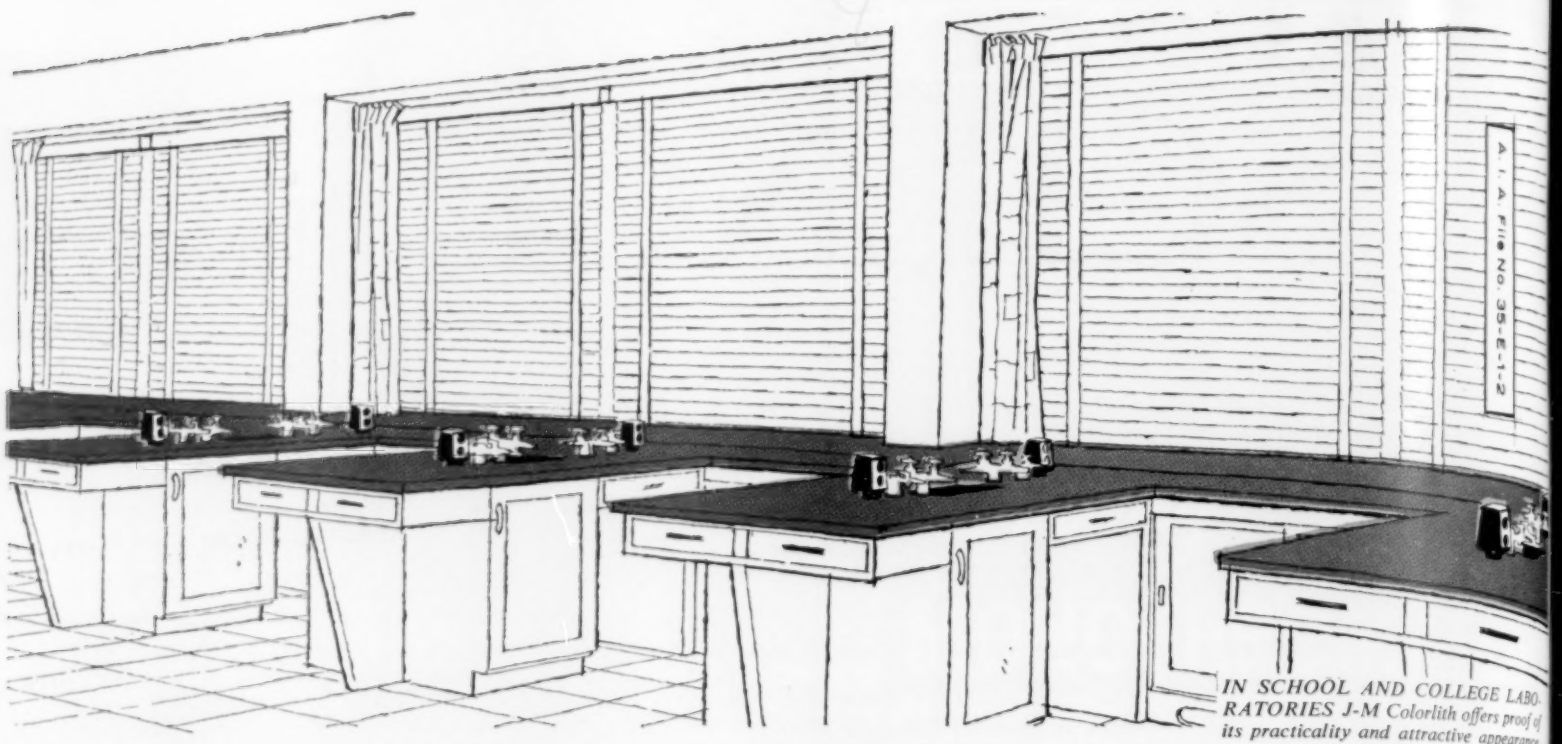

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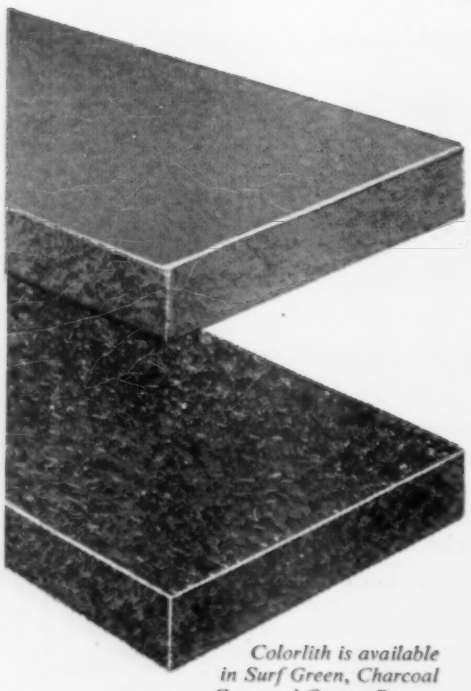

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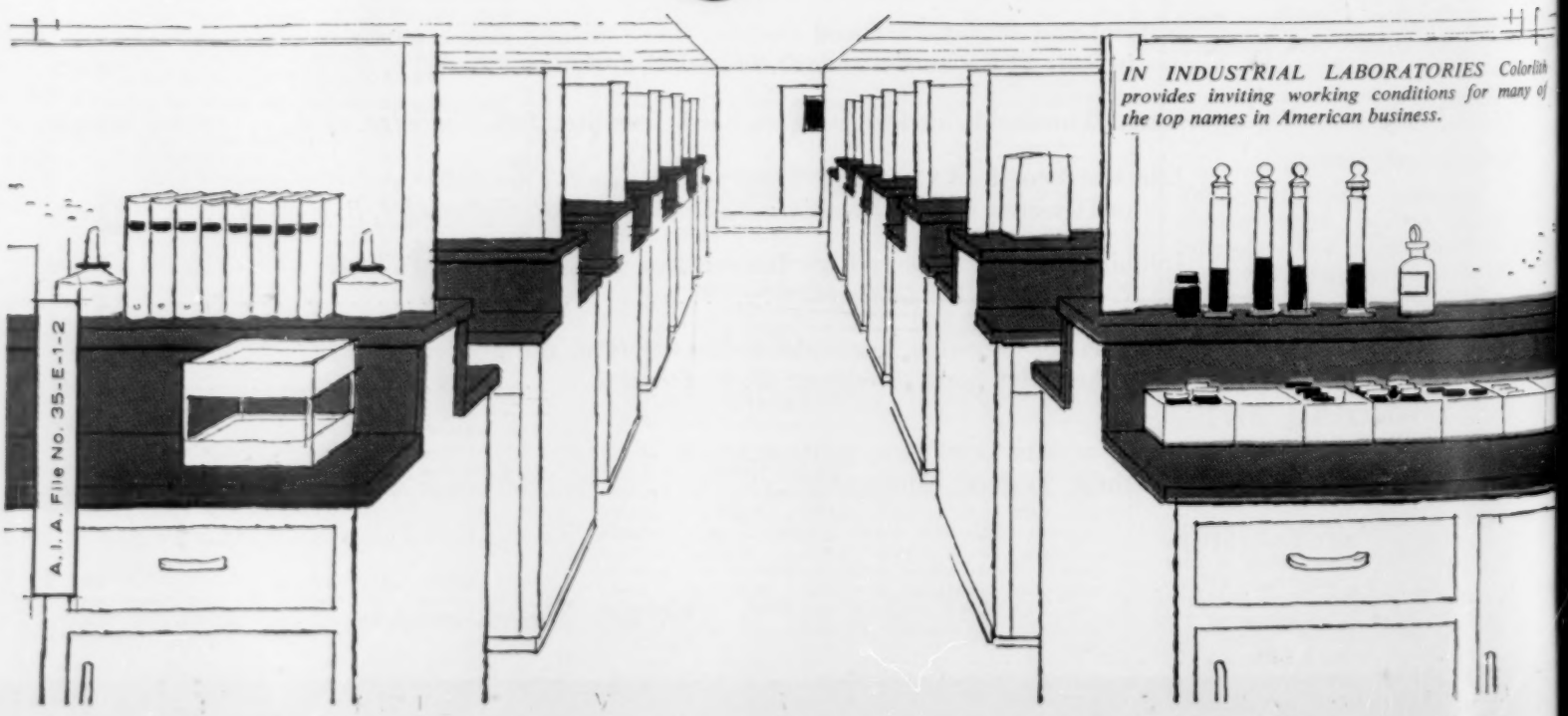

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Federal Support of University Research

That the relations between universities and the Federal Government have been changing in recent years is news to no one, but the extent of the change may be. Federal support of research and development in universities was, in 1940, only about $15 million and was largely confined to agriculture. In a recent report (*Government-University Relationships in Federally Sponsored Scientific Research and Development*), the National Science Foundation estimates that in fiscal 1958 support will amount to about $440 million—a thirty-five fold increase (see page 1231). The greatly increased funds, which possibly amount to two-thirds of the total expenditures of the universities for research and development, now go to the support of all of the natural sciences and engineering as well as agriculture.

The change is not only in the degree but also in the pattern of support. Of the $440 million, the major share, $265 million, still goes to the universities proper, but $175 million is allotted to a comparatively new kind of institution, the research center, that is owned by the Government but is operated under contract by one or more universities or industrial concerns. During the war the need for a vast expansion in scientific and technical knowledge led federal agencies to make contracts with universities and industrial concerns for specific programs. For some projects the demands were so great that the facilities of a particular university department were not adequate to do the job, and this led to the establishment of the research centers.

Of the 47 such centers now in existence, 27 are supported by the Department of Defense, 18 by the Atomic Energy Commission, and 2 by the National Science Foundation; 28 of the centers are operated by universities or groups of universities. Among the major centers operated by universities are the Jet Propulsion Laboratory (California Institute of Technology), Applied Physics Laboratory (Johns Hopkins), Radiation Laboratories (California), Argonne National Laboratory (Chicago), Brookhaven National Laboratory (Associated Universities), and Oak Ridge Institute of Nuclear Studies (Group of Southeastern Universities).

The benefits of this program to the nation and to the universities themselves are obvious, but there are questions about the threats to the independence of the universities and to the freedom in selection of research programs. The Foundation raises some of the questions in its report: "To what extent has the availability of funds from particular agencies given direction to research in universities? Have the policies of the agencies distributing funds and the philosophy of universities in seeking or accepting funds been factors in guiding research? Has the type of work done been determined by the availability of extra-university funds for certain kinds of research?"

The Foundation comes to the general conclusion that, although research has necessarily been given some direction, "this direction up to the present has in general been neither necessarily irksome nor detrimental." That this statement is on the whole true is a tribute to the care and restraint that the federal agencies have exercised in their arrangements with universities.
—G. DuS.

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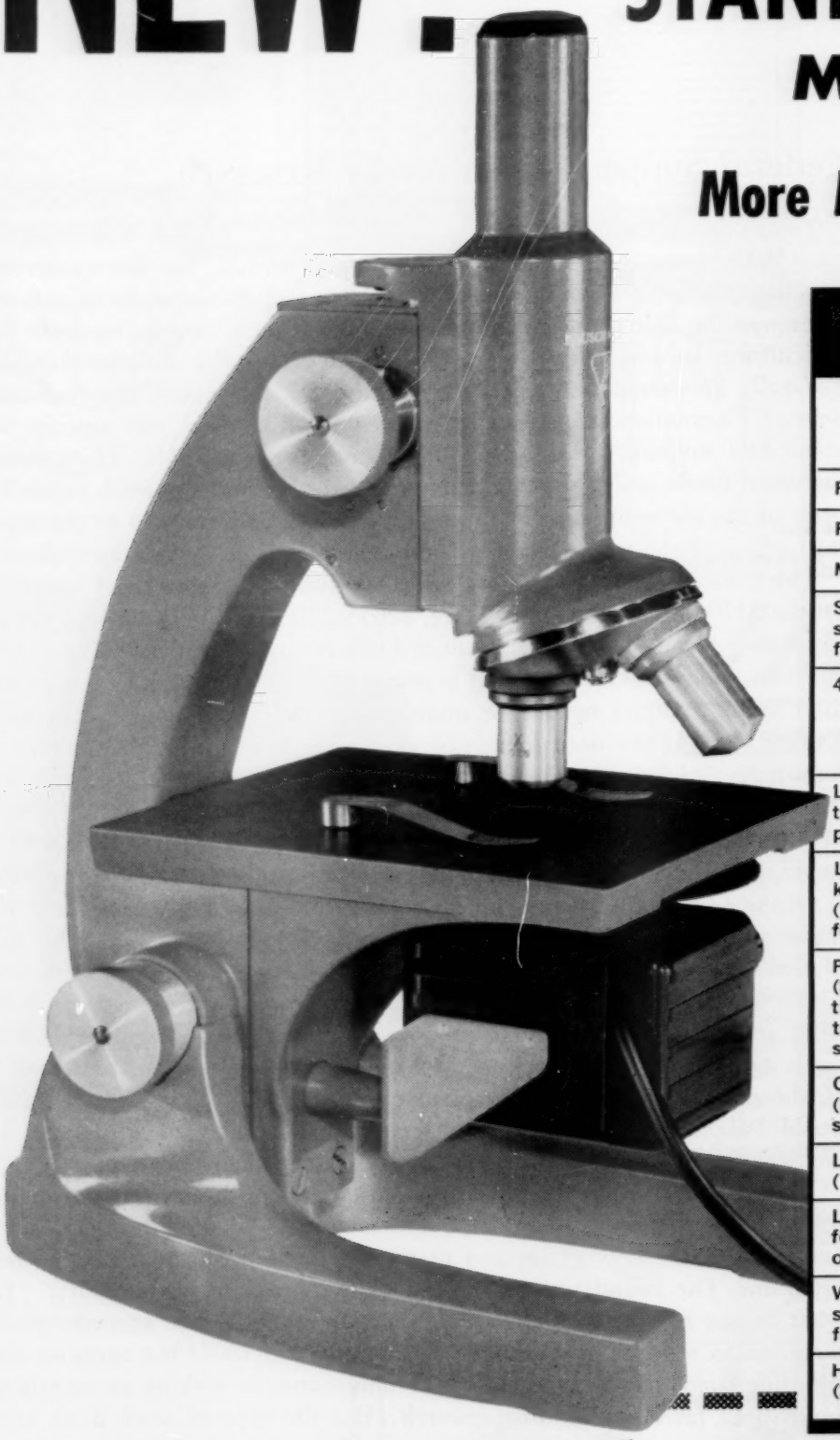

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23 May 1958, Volume 127, Number 3308

SCIENCE

The Chemist's Most Creative Years

The 2500 ablest of the world's chemists attained their maximum production rate at ages 30 through 34.

Harvey C. Lehman

In 1835, just 123 years ago, two great chemists, J. J. Berzelius and J. A. B. Dumas, met in Paris. According to Dumas' brother (*1*, p. 117), their meeting was marked by an odd verbal exchange.

"Upon entering the room where Dumas was waiting for him, the most illustrious among illustrious chemists took Dumas by the hand, and looking him straight in the eye, said:

"'How old are you?'

"'Thirty-five.'

"'That's fine! You still have 20 years of profitable research ahead of you. After 55 one does nothing important in the field of chemistry.'

"This remark gave the conversation a grave and almost an emotional turn. Upon leaving Berzelius, Dumas could not help thinking of the age of the great man who, born in 1779, was now exactly 55, and who had indicated that his present age marked the end of his important work in chemistry."

What justification did Berzelius have for making this remark? The grave turn in the conversation implies that he probably was not trying merely to make small talk. In making this remark Berzelius was perhaps expressing a mere impressionistic judgment for, in so far as is known, he made no statistical study of the problem.

Dr. Lehman is a member of the department of psychology of Ohio University, Athens.

Today the record is 123 years older than it was when Berzelius and Dumas met. We have far more data available than they had, and it is now possible to give Berzelius' pronouncement a careful examination. That is what I have done in this article (*2*) by use of data obtained from 44 histories of chemistry by authors from five different countries—namely, Germany, France, England, Italy, and the United States—22 of them published since 1940 (*1*; *3–45*).

As was implied in the preceding paragraph, this study deals with the age at which the important work of the great research chemist is at an end. I have found, among other things, that although, after he has passed his thirties, the production rate for the most brilliant chemist's extremely important creative work tends to fall off both earlier and more rapidly than does the production rate for his own less brilliant output, no abrupt change occurs at any one age level (*46*). It therefore is not valid to say that the chemist's important contributions are *at an end* at any time prior to his death.

As compared with the masterworks of the less brilliant research workers, the masterworks of the most able research workers are produced by men who are of more nearly the same age. The more brilliant the chemist, the earlier the age at which he gives genuine indications of his future greatness. Although the great chemist's first research work is usually not his best, there are some conspicuous exceptions to this rule. After they started upon their professional careers, the most able chemists progressed faster than their less able colleagues. The 54 ablest chemists have attained their highest production rates and, hence, have contributed the greatest proportion of their very best work during the 15-year interval from ages 25 to 39, inclusive; the higher the caliber of the group, the larger the proportion of their masterworks contributed during this 15-year interval. When due allowance is made for the death rate, it is found that, collectively, the 2500 greatest of the world's chemists have attained their maximum production rate at ages 30 to 34, inclusive.

In what follows no attempt is made to tell what could, or should, or would have happened, under some purely hypothetical condition that conceivably might have existed but which did not actually obtain at any time or any place. Nor have I tried to extrapolate the findings. The reader can do his own speculating about what will happen in the days that lie ahead.

Sources of Information

In this study I never assume personal responsibility for identifying or judging the importance of a contribution to chemistry. I depend always upon the appraisals of recognized experts. These several specialists compiled and published their material under their own names, not for the purpose for which I have used it here, but rather for the use of professional chemists. The 44 histories were prepared by authors who had no special interest in the age factor, and it seems obvious that the compilers were concerned not with the ages of the contributors at the time they made their important contributions but rather with the actual significance of the contributions themselves. It seems unlikely, therefore, that the historians have exhibited any special bias with reference to chronological age. Indeed, most of them did not mention the contributors' ages at all, and they probably did not even give

Table 1. Data for contributions to chemistry each of which was cited and discussed in one or more of 44 histories of chemistry.

Row	Group								
	A	B	C	D	E	F	G	H	I
1. Number of contributors	54	30	66	77	109	111	201	385	1433
2. Total No. of works	1199	552	649	813	748	749	1019	1400	2767
3. Average No. of works per chemist	22.2	18.4	9.8	10.7	6.9	6.7	5.1	3.6	1.9
4. Maximum No. of histories citing most renowned works	20 or more	15–19	10–14	7–9	5 or 6	4 only	3 only	2 only	1 only
5. Total No. of works of level of merit indicated in row 4	102	38	70	83	123	125	233	480	2767
6. No. of men whose "one best" work could be identified	53	30	66	76	98	85	178	330	838
7. Percentage of "one best" works first reported after age 55	2	0	5	3	6	6	10	10	12
8. Age prior to which 25 percent of "one best" works were reported	30.13	27.58	29.30	29.42	30.38	30.04	29.30	30.50	30.00
9. Age prior to which 50 percent of "one best" works were reported	34.31	35.50	36.33	35.83	37.25	40.83	36.20	37.22	36.55
10. Age prior to which 75 percent of "one best" works were reported	37.94	39.50	45.25	45.50	45.25	43.75	42.13	46.58	46.95
11. Age range during which middle 50 percent of "one best" works were reported	7.81	11.92	15.95	16.08	14.87	13.71	12.83	16.08	16.95

them a single thought. In preparing their histories they must have been writing as top-notch professional writers always write, and it seems safe to assume that, collectively at least, they must have exhibited good professional judgment.

From each history I copied down the name of each contributor to chemistry each time that it appeared if the historian also mentioned both a specific contribution and a specific calendar date that would enable me to know when the contribution was either first made or first reported. When the histories gave birth and death dates or the national origin of the contributor, or all of these data, that information was also noted. When birth and death dates and the country of origin could not be obtained from these histories, I obtained that information when possible from other sources.

By subtracting the date of birth of each contributor from the date on which he made or first reported his several contributions, it was possible to determine the ages of the contributors at the time they reported their contributions. Some allowance must be made, of course, for the time that may have elapsed between the inception and completion of a brilliant scientific study and between the latter date and that on which the achievement was first reported or published. Since the chemists always reported their contributions after, and never prior to, making them, the contributors must have been somewhat younger at the time they made their contributions than my data indicate.

The names of all the contributors found in each history were later typed in alphabetical order, with the aforementioned information set down after each contributor's name. This procedure yielded 44 separate lists of names. When the factual information from all 44 histories had been typed in duplicate, I used the duplicate lists to make one long master list containing, in alphabetical order, (i) the names of all contributors; (ii) their birth and death dates; (iii) the calendar dates on which they had reported their several contributions; (iv) their ages at the time they first reported each contribution; and (v) the number of different histories that cited and discussed the work reported by each contributor during any one calendar year.

This last item of information was later employed on the assumption that a group of contributions each of which was cited and discussed in, say, 15 or 20 histories of chemistry is of greater importance to chemistry than is another group of contributions each of which is cited and discussed in only one or two such histories.

In the handling of my data no count was made of the number of times a particular contribution was mentioned and discussed between the covers of any one history, but if several different contributions were made by the same individual during any one calendar year, each was counted. This means that a particular history might credit a given chemist with one specific contribution at a given chronological age level or it might credit him with several.

In making my master list I simply totaled the number of different credits (or tallies) thus obtained from the 44 histories. Therefore, in the reading of this article it should be understood that the words *contribution* and *masterwork* refer not necessarily to one specific achievement but rather to the entire output that each chemist reported during any one calendar year. In most instances we know that this output consisted of one outstanding discovery, but this is not true in all cases. The reader should keep this fact in mind constantly, for it would be awkward to incorporate it in each of the numerous statements I shall make later in which I use the words *contribution, one best contribution,* and so on.

Table 1 presents information regarding 9896 chemistry "contributions" each of which was of sufficient importance to be cited and discussed in one or more of the 44 histories. Table 1 sets forth the data for deceased chemists only, and only for those born not less than 70 years prior to publication of each history from which I obtained data. The figure of 70 years prior to the date of publication of each history from which data were obtained regarding a given chemist was set as an arbitrary dividing line in order to avoid the possible overloading of my findings with data on contributors born quite recently.

Data on living individuals are excluded from Table 1 because it obviously is not possible to study the entire life-work of chemists who are still living and achieving. In the first place, it is almost impossible to judge the actual significance of quite recent work. The impor-

tance of a chemistry contribution depends on its ultimate fruitfulness, and the ultimate fruitfulness of any scientific finding cannot be known for a good long time—if ever. Moreover, we have no sure way of knowing what the living chemist will accomplish during his later years. Table 1 includes, therefore, the data for deceased individuals only. For these the record is reasonably complete, and future events will probably change it only slightly if at all.

Sorting of Contributors and Their Contributions

The first row of Table 1 reveals the number of different contributors who attained the level of merit indicated in row 4. It shows, for example, that each of 54 chemists of group A (the most brilliant group) made one or more contributions each of which is cited and discussed in not fewer than 20 of the 44 histories, and that each of the 30 chemists of group B made one or more contributions that is mentioned and discussed in from 15 to 19 histories, and so on. Row 2 of Table 1 gives, for each group, the total number of its contributions that appear in my master list, including those of relatively minor importance. Row 3 reveals the average number of works per man within each group and indicates among other things that the average output per man (22.2 works) for group A, the most renowned group, was much greater than that (1.9 works) for group I, the least renowned group.

The fifth row of Table 1 shows the total number of works of the level of merit indicated in row 4, produced collectively by the members of each group. For example, although the 54 chemists of group A made a grand total of 1199 contributions which appear on my master list, only 102 of these contributions were cited and discussed in as many as 20 or more histories. And, although group B made a grand total of 552 contributions which appear on my list, only 38 of these contributions were cited and discussed in from 15 to 19 of the histories.

"One Best" Contribution

A chemist's one best contribution, by definition, can be made once only. Hence, if two or more of a chemist's choicest contributions were discussed in an equal number of histories, I ignored that chemist's work in preparing row 6 of Table 1 because I could not identify with certainty his one best contribution. Row 6 of Table 1 was obtained by working from this premise. It reveals the number of individuals in each group who made one contribution that was cited and discussed in more histories than was any other of their contributions. Row 7 shows the percentages of these "one best" performances that were first reported when the contributors were beyond 55 years of age. This is what interested Dumas. Notice that, of the 53 "one best" contributions made by group A, only one (or 2 percent) was first reported by a contributor over age 55. This happens to be the work of Hermann Boerhaave (1668–1738), Dutch physician and famous professor of medicine at the University of Leyden. Though he made no fundamental chemical discovery, Boerhaave's famous five-volume textbook, the *Elementa chemiae,* written we know not when but first published in 1724, when he was 56, received mention in 26 of the 44 histories.

In row 7, as one reads from left to right, the percentages grow larger. This means, of course, that the more noteworthy the chemist's one best contribution, the less likely it is that the contribution will be reported by a chemist who is over 55 years old. This statement applies not to the chemist's potential achievement at successive age levels but only to the achievement which was realized by the chemists included in the present study. One should also make a distinction between the chemist's one best contribution and his important work. Even though, if it is a highly important one, the chemist's one best contribution will probably be made before he is past 55, the work which he does beyond that age may still be very important.

Best Work of Berzelius and Dumas

On my master list, Berzelius received a grand total of 493 tallies, and in this respect he ranked first in my entire list. Dumas ranked seventh, with a grand total of 296 tallies. Although by use of this procedure one probably cannot hope to rank chemists in order of their importance with mathematical accuracy, it nevertheless seems clear that both Berzelius and Dumas are among our foremost chemists. Research that Dumas did at age 34 is cited in 37 of the 44 histories. Although Dumas lived to be 84 years old and although he made eight contributions after he was 55 which appear on my master list, he reported nothing in any one year after age 55 which is cited in more than six of the 44 histories. However, to receive mention in as many as six of 44 histories of chemistry is no mean achievement, regardless of the age at which the work is done.

As for Berzelius—my master list reveals that work reported by him at age 35 is cited and discussed in 26 of the 44 histories and that he reported nothing quite so important after he was past 55. However, he did make 13 contributions that appear in my master list when he was beyond 55, and at age 56 he reported some research that is cited in 17 of the 44 histories. This is very remarkable for a man of any age. It is obvious that both Berzelius and Dumas did more important research in chemistry when they were beyond age 55 than most other chemists have done in their palmiest days. It is also to be borne in mind that some very able chemists receive no mention at all in histories of chemistry.

If, at the time of their meeting in 1835, Dumas could have peered into the histories of chemistry that were to be published long after his death, he probably would have been amazed to discover that he, at age 34 in 1834, and Berzelius, at age 35 in 1814, had already reported their most notable research.

Ages at Which Maximum Production Rate Is Attained

The eighth row of Table 1 shows, for members of the several groups, the ages prior to which the first 25 percent of their masterworks (*47*) were produced. For example, the number for group A in row 8 (30.13) reveals that the earliest 25 percent of the 53 masterworks cited and discussed in each of 20 or more of the 44 histories were first reported when the member of the group who reported it was not beyond age 30.13. The last figure in this row (30.00) shows, for group I, that the first 25 percent of its 838 contributions were made when the individual who did the reporting was not more than 30.00 years old.

The ninth row of this table presents the ages prior to which the first 50 percent of the contributions of members of each group were made, and the 10th row reveals the ages prior to which 75 percent of their contributions were made. Although the age differences shown in row 8 are slight and those shown in row 9 are also small, row 10 highlights again the fact that the age range for produc-

Table 2. Ages at which groups of chemists first reported contributions to chemistry cited and discussed in one or more of 44 histories of chemistry.

Row	Group							
	A	B & C	D	E	F	G	H	I
1. Maximum number of histories in which most-renowned contribution to chemistry is cited	20 or more	10–19	7–9	5 or 6	4 only	3 only	2 only	1 only
2. Number of contributors	54	96	77	109	111	201	385	1433
3. Age prior to which 25 percent of initial contributions were made	21.71	22.18	24.54	25.75	24.71	26.41	27.08	28.90
4. Age prior to which 50 percent of initial contributions were made	24.71	26.28	27.90	28.42	29.00	30.30	31.42	33.71
5. Age prior to which 75 per cent of initial contributions were made	27.90	32.69	32.63	36.13	35.75	36.81	39.81	42.88
6. Five-year interval during which largest number of initial contributions were made	18–22 tied with 21–25	22–26 (B) 22–26 (C)	23–27	25–29	24–28	24–28	26–30	29–33

tion of a masterwork of very great importance is narrower than that for production of a masterwork of lesser importance. Notice in row 10 that, whereas the last 25 percent of the masterworks of group A appeared when the contributors were past age 37.94, the last 25 percent of the relatively minor masterworks of group I appeared when the contributors were beyond age 46.95.

The last row of Table 1 brings out even more clearly the fact that the most brilliant masterworks are produced by men who are of more nearly the same age than is the case when the masterworks are of less significance. Notice in row 11 that half of the 53 most brilliant masterworks in chemistry appeared during an age range of only 7.81 years but that half of the 838 masterworks of lesser merit appeared during an age range of 16.95 years. One would naturally expect half of only 53 contributions to be produced over a shorter span of years than half of 838 contributions. But why were half of the 53 most brilliant contributions (those cited by the largest number of histories) made at ages 30.13 to 37.94 rather than during some other age range of equal length—say, from ages 40.13 to 47.94, or from ages 50.13 to 57.94, for example? One can only conjecture with reference to this. At present there is no sure answer.

First Important Contributions

At what ages do the greatest chemists first show genuine indications of their future greatness? Table 2 reveals the ages at which the members of each group first published contributions important enough to be cited in one or more of the 44 histories and, therefore, important enough to appear on my master list. In this table the groups are again segregated according to the frequency with which their most renowned contribution to chemistry was cited and discussed in the 44 histories.

The first numeral in row 3 reveals that 25 percent of the members of group A *first* published a contribution important enough to be on my master list prior to age 21.71. The last numeral in this row shows that 25 percent of the members of group I did not attain this level of success until they were 28.90 years old. Row 4 indicates similarly that, whereas prior to age 24.71 half of the members of group A had done research of sufficient merit to be cited in one or more of the 44 histories, half of the members of group I did not attain this distinction until nine years later—namely, at age 33.71. The fifth row of Table 2 is even more striking. It shows that, whereas three-fourths of the most brilliant group had published research that appears on my master list by the time they were 27.90 years old, three-fourths of the least brilliant group did not reach this milestone of success until they were 15 years older—namely, at age 42.88.

The last row of Table 2 reveals the five-year interval during which the maximum number of initial contributions to chemistry were produced. Study of all the data in Table 2 reveals an unmistakable trend—namely, that the more brilliant research chemists have started their professional careers at earlier ages than have the less brilliant ones.

Table 3. Average number of contributions to chemistry made prior to age 25 which were cited and discussed in (i) one or more, (ii) two or more, and (iii) three or more histories. The largest average in each of rows 3, 4, and 5 was assigned an arbitrary value of 100 percent, and the other frequencies in the same row were then assigned proportionate percentage values.

Row	Group							
	A	B & C	D	E	F	G	H	I
1. Maximum No. of histories citing "one most renowned" contribution	20 or more	10 to 19	7 to 9	5 or 6	4 only	3 only	2 only	1 only
2. Number of contributors	54	96	77	109	111	201	385	1433
3. Average No. of contributions cited in one or more histories	1.81 (100%)	0.80 (44%)	0.43 (24%)	0.25 (14%)	0.33 (19%)	0.28 (16%)	0.21 (12%)	0.11 (6%)
4. Average No. of contributions cited in two or more histories	0.833 (100%)	0.444 (53%)	0.260 (31%)	0.101 (12%)	0.144 (17%)	0.104 (13%)	0.099 (12%)	
5. Average No. of contributions cited in three or more histories	0.667 (100%)	0.311 (47%)	0.156 (23%)	0.055 (8%)	0.081 (12%)	0.065 (10%)		

Contributions Prior to Age 25

Table 3 reveals for the several groups, the average numbers of contributions made prior to age 25 which are cited in (i) one or more histories, (ii) two or more histories, and (iii) three or more histories. The first numeral in row 3 shows that members of group A had made an average of 1.81 contributions (each of which was important enough to place their names on my master list) before they were 25 years old. In order to facilitate comparison with the other groups in row 3, the numeral 1.81 was assigned an arbitrary value of 100 percent, and the remaining frequencies in this distribution were then assigned proportionate percentage values. As one reads along this row of percentages it will be noted that no other group did half as well prior to age 25 as did group A. And it can be seen also that, prior to age 25, the least renowned group in the list (group I) did less than 10 percent as well as did group A.

Rows 4 and 5 reveal the same general trend as does row 3. For each group in row 4, the average output per man prior to age 25 is smaller than it is in row 3, because row 4 is based upon more select contributions than is row 3. That is to say, contributions which are cited and discussed in two histories of chemistry are probably of somewhat greater average merit than are other contributions which are mentioned in one history only. Similarly, the averages in row 5 are smaller than are the averages in row 4, because contributions which are cited in three or more histories are probably of greater merit than are those which are mentioned in two histories only. From rows 3, 4, or 5 it is clear that members of the two first groups (A and B–C) got off to an earlier start than those of other groups. And, as was shown in Table 1, once they were launched upon their professional careers, they moved faster and they went further than did the members of the other groups.

More Brilliant versus Less Brilliant Contributions

Table 4 sets forth, by five-year intervals, both the number and the percentages of contributions to chemistry that were cited and discussed (i) in one only of the 44 histories and (ii) in 20 or more of the 44 histories. This table reads as follows: Of the 6347 contributions to chemistry each of which was mentioned in one only of the 44 histories, 1 percent were contributions made at ages 15 to 19, inclusive, 5 percent were made by contributors of ages 20 to 24, inclusive, and so on.

Notice in this table that, whereas 71 percent of the major contributions to chemistry were produced at ages 25 to 39, inclusive, only 43 percent of the relatively minor ones were reported during this same 15-year interval. Notice, also, that whereas only 5 percent of the major contributions were reported by contributors of age 50 or above, 26 percent, or approximately five times as large a proportion, of the relatively minor contributions were first reported by contributors who were 50 or more years of age at the time of reporting them. Table 5 reveals the relationship even more clearly than does Table 4: the greater the merit of the contribution to chemistry, the smaller the percentage of contributions of this degree of merit that have been produced at age 50 or beyond.

Greatest Chemists' Extremely Important Contributions

Although my data speak for themselves, graphs will enable me to present the picture more clearly than is possible by use of only words and numerals. Figure 1 reveals the ages at which 54 noted chemists made 155 very superior contributions to their field, each of the 155

Table 4. Grand total of all contributions to chemistry that were made by the various age groups and that were cited and discussed in: (i) one only of 44 histories and (ii) 20 or more of the 44 histories.

Age group	Histories			
	One only		20 or more	
	No.	(%)	No.	(%)
15–19	51	1	1	1
20–24	321	5	4	4
25–29	799	13	16	17
30–34	978	15	28	27
35–39	956	15	28	27
Total 25–39		(43)		(71)
40–44	841	13	12	12
45–49	709	11	8	8
50–54	595	9	4	4
55–59	406	6	1	1
60–64	325	5		
65–69	195	3		
70–74	111	2		
75–79	44	1		
80–84	12	< 1		
85–89	4	< 1		
Totals	6347	100	102	101

Table 5. Percentages of all contributions made at age 50 or beyond that were cited and discussed in different numbers of 44 histories of chemistry.

No. of histories	Percentage
1 only	27
2 only	22
3	22
4	22
5 or 6	19
7 to 9	15
10 to 14	13
15 to 19	6
20 or more	5

contributions being cited and discussed in not fewer than 15 of the 44 histories of chemistry. My several tables did not take the death rate into account, but in a study of Fig. 1 it should be understood that it sets forth the average number of contributions per five-year interval. Ample allowance is thus made for the fact that time takes its toll and, therefore, that young chemists always comprise a larger group than do older ones. For example, it was found that for the five-year interval from age 30 to 34, inclusive, the 54 chemists made 43 of the contributions that are represented in Fig. 1. This was slightly more than 0.159 contributions per individual. The chemists that remained alive at age 60 to 64 made only two of these superior contributions, which was slightly more than 0.00971 contributions per living contributor. The solid line in Fig. 1 is drawn so as to be only 0.00971/0.159 as high at ages 60 to 64 as it is at ages 30 to 34. The curve is drawn in this manner in order to show graphically that the average number of contributions per living chemist—that is, their production rate—was only 0.00971/0.159 as large at age 60 to 64 as it was at age 30 to 34.

If, regardless of the number that remained alive, the older chemists had contributed at the same average rate as did the younger ones, the curve in Fig. 1 would remain as high at the higher age levels as at the lower levels. Actually, Fig. 1 exhibits a very noticeable and consistent decrement at the uppermost age levels, thus indicating that, with regard to these superior contributions, the chemists became progressively less productive at the higher age levels.

One other point should be mentioned with reference to Fig. 1. In the construction of this figure, the peak of the statistical distribution was arbitrarily assigned a value of 100 percent, and the other averages within this statistical distribu-

Table 6. Average number of contributions to chemistry per age interval (absolute values used for the construction of Figs. 1 through 7

Ages	Fig. 1	Fig. 2* dot-dash line	Fig. 3† dot-dash line	Fig. 4‡ broken line	Fig. 5			Fig. 6			Fig. 7§	
					Solid line	Dot-dash line	Broken line	Solid line	Dot-dash line	Broken line	Solid line	Dot-dash line
15–19	0.004	0.001	0.052	0.070		0.005	0.005		0.006	0.007	2	2
20–24	0.015	0.016	0.170	0.285	0.017	0.054	0.118	0.008	0.027	0.041	27	26
25–29	0.096	0.031	0.196	0.500	0.047	0.133	0.330	0.038	0.087	0.141	92	81
30–34	0.159	0.040	0.167	0.559	0.039	0.146	0.370	0.038	0.104	0.168	100	100
35–39	0.141	0.031	0.204	0.630	0.043	0.121	0.360	0.042	0.108	0.179	92	96
40–44	0.079	0.025	0.267	0.639	0.015	0.143	0.323	0.029	0.100	0.148	60	60
45–49	0.048	0.021	0.259	0.522	0.022	0.113	0.308	0.023	0.080	0.121	51	51
50–54	0.027	0.015	0.275	0.518	0.015	0.120	0.233	0.018	0.070	0.101	29	34
55–59	0.010	0.013	0.243	0.451	0.007	0.086	0.180	0.011	0.044	0.065	19	21
60–64	0.011	0.010	0.205	0.316	0.004	0.097	0.153	0.010	0.046	0.062	17	20
65–69		0.005	0.197	0.270		0.094	0.125	0.003	0.025	0.030	8	8
70–74		0.005	0.180	0.253		0.050	0.061	0.002	0.022	0.025	2	2
75–79		0.001	0.071	0.143		0.042	0.056	0.003	0.016	0.020		
80–84		0.001	0.097	0.097		0.015	0.015		0.007	0.007		
85–89			0.143	0.143		0.021	0.021		0.007	0.007		

* The solid line of Fig. 2 is the same as the curve in Fig. 1.
† The solid line of Fig. 3 is the same as the curve in Fig. 1.
‡ The solid line of Fig. 4 is the same as the curve in Fig. 1; the dot-dash line of Fig. 4 is the same as the dot-dash line of Fig. 3.
§ The two rows of Fig. 7 contain percentage values because each statistical distribution was converted to percentage values before the median values were ascertained.

tion were then assigned proportionate percentage values. For example, the peak of the distribution represented in Fig. 1 occurred at ages 30 to 34. This modal value was taken to be 100 percent, and the remaining frequencies were then computed and plotted as percentages of this modal value. Table 6 reveals the absolute values used for the construction of Figs. 1 through 7. It is of interest to note that these rather small decimal values yield fairly consistent and revealing age curves.

Age Range for Masterworks of Lesser Chemists

In order to reveal its similarity to certain other age curves, Fig. 1 is reproduced in Figs. 2 and 3 and drawn to a different scale in Fig. 4. Thus, the solid line of Fig. 2 is identical with that of Fig. 1. It represents, for group A, 155 contributions each of which was cited in not fewer than 15 of the 44 histories. The dot-dash line of Fig. 2 represents, on the other hand, the ages at which each of 1166 chemists produced their masterworks, each of these 1166 masterworks being cited and discussed in not more than one or two of the 44 histories of chemistry. Figure 2 thus shows that 54 of the greatest chemists reported 155 of their most important contributions during a narrower age-range than that during which 1166 lesser chemists reported their masterworks.

In the construction of the two curves of Fig. 2, the same procedure was adhered to as was employed for constructing Fig. 1. That is to say, the maximum value of each distribution used for making Fig. 2 was assigned a value of 100 percent, and the other values within each distribution were then plotted as percentages of the distribution's modal value. It should be clear that, since both modal values of Fig. 2 were arbitrarily assigned values of 100 percent, the equal heights of the two curves of Fig. 2 result from the way they were drawn and this should not be taken to mean that the two maximum production rates were the same numerically.

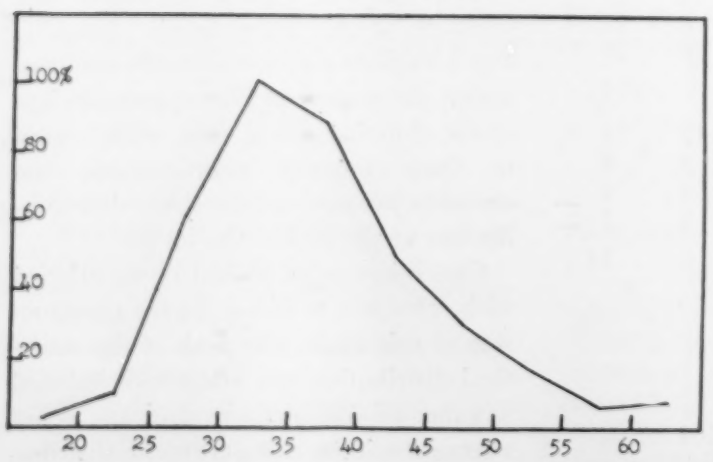

Fig. 1. Relationship of age (abscissa) to rate of production in chemistry. The curve represents average rate of production of 155 very superior contributions by 54 chemists (group A), each contribution having been cited and discussed in not fewer than 15 of 44 histories of chemistry.

Most Brilliant versus Less Brilliant Work of Greatest Chemists

Figure 3 shows that the greatest chemists have made their most noteworthy contributions during a narrower age range than that during which they have produced their relatively minor ones. In Fig. 3, the solid line is again a reproduction of that in Fig. 1. The dot-dash line of this figure represents data for 550 of group A's relatively minor contributions each of which was cited in not more than two of the 44 histories. Obviously these latter contributions were not the very best contributions of group A. On the contrary, it seems reasonable to assume that the solid line in Fig. 3 shows the production rate for group A's most brilliant attainments and that the dot-dash line in this figure represents the production rate for 550 of group A's less brilliant works.

It will be noticed in Fig. 3 that the curve for the less meritorious contributions rises earlier, attains its peak later—namely, at ages 40 to 44—and does not terminate until it reaches a fairly advanced age level. The slower rise of the curve for the more important contributions suggests that the chemist's first research effort is usually not his most fruitful one. Although this is generally true

there are more exceptions to this rule than might be expected.

Without such information as is revealed by Fig. 3, it might be supposed that because men may be in their best physical condition at ages 30 to 34, they are best able at this time to put in long hours of work and withstand fatigue, and that for such reasons they have worked hardest at ages 30 to 34, attaining at these ages their highest production rate for work of every caliber—their best, their good, and their least brilliant. But Fig. 3 reveals that such a conjecture is not wholly valid. Whereas group A's production rate for its best work was greatest at ages 30 to 34, for its least meritorious work (as found on my master list) it attains its highest production rate not at ages 30 to 34 but at ages 40 to 44.

Note also that, whereas the solid line is highest at ages 30 to 34, the dot-dash line dips slightly at this age level. This phenomenon probably means only that when men are producing their most notable contributions they are not likely simultaneously to be producing their least notable ones.

There probably are a great many reasons for the finding that older chemists are likely to do less important research than younger ones. Let us consider the case of Dumas once more by way of illustration. Before he was 21 years old Dumas was engaged with J. L. Prevost in original work on problems of physiological chemistry. Here we have an example of a gifted young worker who made an early start upon his professional career. From 1840 (age 40) he was one of the editors of the *Annales de chimie et de physique*. In 1849 he became a member of the French National Legislative Assembly; he acted as minister of agriculture and commerce in 1850–51, and he subsequently became a senator, president of the municipal council of Paris, and master of the French mint. It is difficult to see how, during his later years, Dumas, with all these other commitments, could possibly have given his undivided attention to research in chemistry. Obviously, he could not have done so.

Uneven Work of Greatest Chemists

It was explained earlier that in Fig. 2 the two curves are of the same maximum height because they are drawn that way and that this should not be interpreted as implying that the maximum production rates are therefore identical. Figure 4 is plotted differently. In this figure

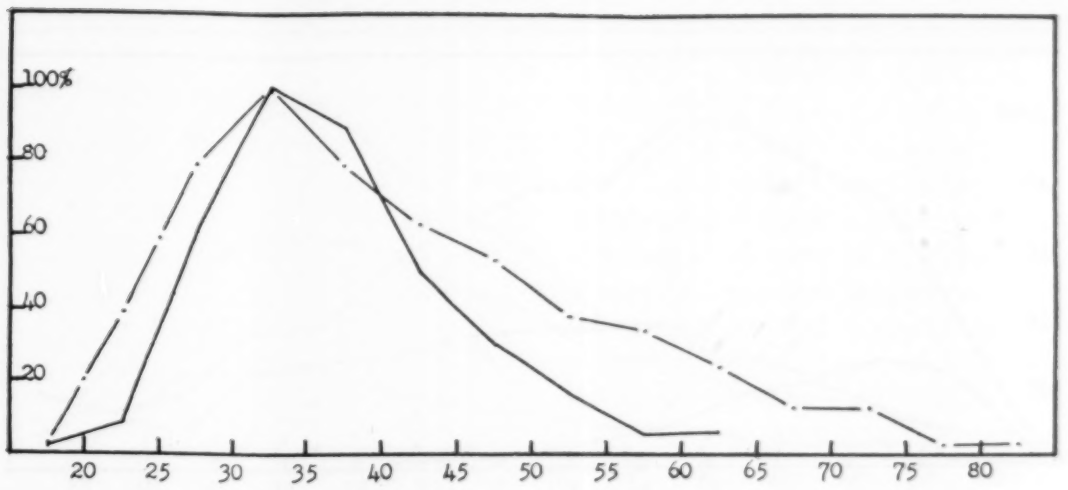

Fig. 2. Relationship of age (abscissa) to rate of production. The solid line represents the same data for the 54 chemists of group A as in Fig. 1. The dot-dash line represents average rate of production of the "one best" contribution (cited and discussed in only one or two of 44 histories of chemistry) by each of 1166 chemists.

the broken line represents the production rate for all of the contributions on my master list that were made by the members of the peerless group A. It represents the production rate for 1199 works, an average of 22.02 works per man. The dot-dash line represents the same data as the dot-dash line of Fig. 3 but is drawn to a different scale. This dot-dash line represents the production rate for group A's least meritorious 550 contributions. And the solid line of Fig. 4 shows, for group A, the production rate for its 155 most brilliant achievements. The broken line of Fig. 4 covers a greater area than do the two smaller curves because this broken line is based upon a larger number of contributions—namely, the 155 most brilliant, plus the 550 least brilliant, plus 498 other contributions each of which was cited and discussed in from three to 14 of the 44 histories.

Although both curves of Fig. 3 are reproduced in Fig. 4, neither of them looks the same in Fig. 4 because in Fig. 4 the peak of the curve for *total* output was assigned a value of 100 percent and all other averages in all three distributions were then assigned proportionate percentage values. Thus, in Fig. 4, the peak of the dot-dash line is only 42 percent as high as is the peak of the broken line, because numerically the maximum production rate for the least valuable contributions of members of group A (those contributions that are cited in only one or two of the 44 histories) never exceeded 42 percent of the maximum production for the total output of members of this group.

Similarly, the peak of the solid line in Fig. 4 is only 25 percent as high as is the peak of the broken line, because the maximum production rate for the most brilliant contributions (those cited in 15 or more of the 44 histories) never exceeds 25 percent of the maximum production rate for total output. Figure 4 merits close study. For the three groups of contributions, the maximum production rates occur at the following ages: (i) for the most brilliant, at ages 30 to

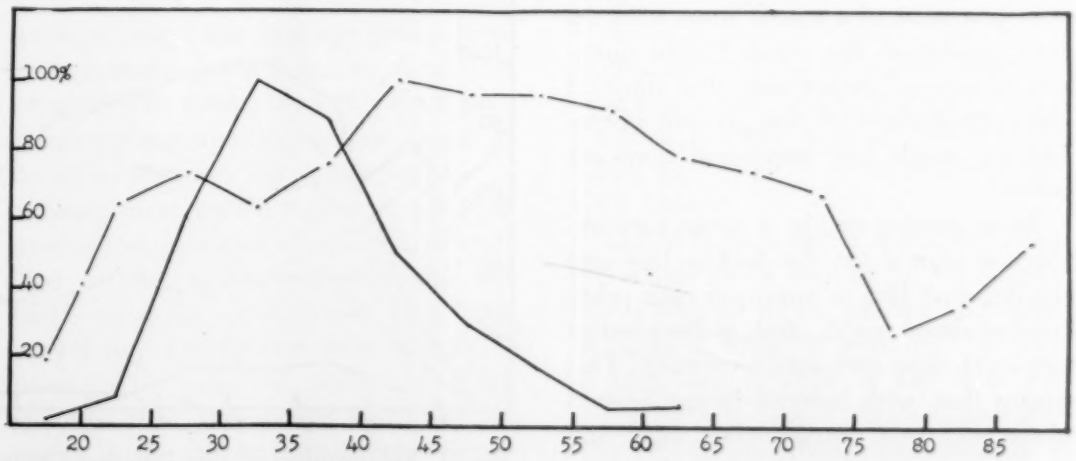

Fig. 3. Relationship of age (abscissa) to rate of production of two categories of contributions by the 54 chemists of Figs. 1 and 2. The solid line represents the same data as in Fig. 1. The dot-dash line represents average rate for 550 relatively minor contributions, each having been cited and discussed in not more than two of 44 histories of chemistry.

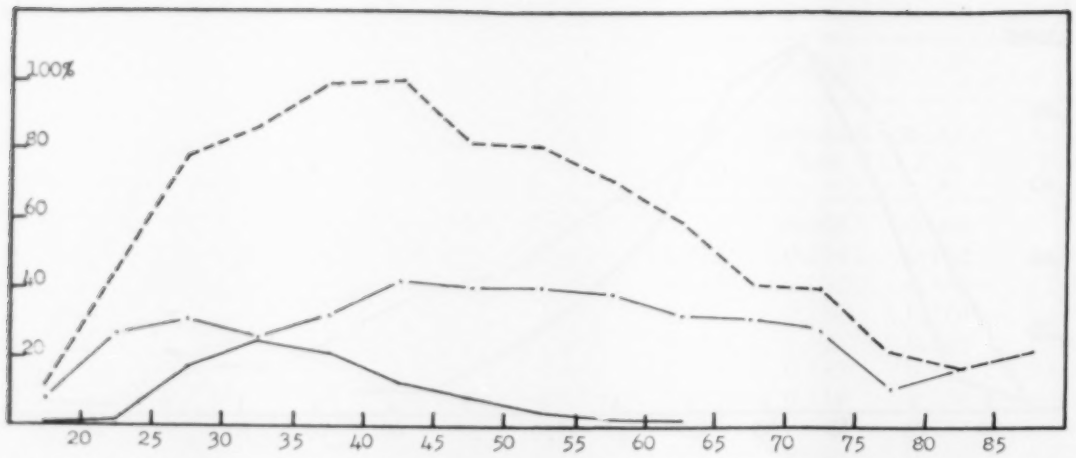

Fig. 4. Relationship of age (abscissa) to rate of production of two categories of contributions and of total contributions by the 54 chemists of Figs. 1–3. The solid line and the dot-dash line represent the same data, respectively, as the solid and dot-dash lines in Figs. 1 and 3 (drawn to a different scale). The broken line represents average rate for 1199 contributions that constitute the total output of this group, as revealed by a master list.

34, (ii) for the least brilliant, at ages 40 to 44, and (iii) for the total output, at ages 40 to 44. The fact that in this graph the curve that indicates maximum production rate for the most brilliant contributions never reaches the level of that for the least brilliant results from the way in which the two groups of contributions were chosen. One would hardly expect the maximum production rate to be as great for 151 as for 550 contributions.

Beyond age 45 the production rate for the least brilliant achievements holds up surprisingly well, but after the chemist has passed his thirties, the production rate for his creative work of highest quality tends to fall off more rapidly than does the production rate for mere quantity of output. In employing the expression "mere quantity of output" I do not mean to express scorn for what the members of group A achieved during their later years. These men were and are the most brilliant ornament of their profession, and their least important works are all masterpieces in comparison with the very best work of a host of lesser men. As here employed, the words "mere quantity of output" imply only that some of the contributions of our greatest chemists are much less important than are others.

Most striking in Fig. 4 is the very obvious tendency for the broken line and the dot-dash line to approach each other beyond about age 45. And, at the greatest age level, these two curves coincide. This means that, with increase in age beyond about 45, total output tends more and more to consist solely of relatively minor contributions. But this age change is very gradual, and no abrupt change occurs at any one age. It therefore is not valid to say that the great chemist's important work is ended at any one time prior to his death. The contributions made by the members of group A during their later years, though relatively minor as compared with their most brilliant contributions, were *in toto* important.

Uneven Work of Lesser Chemists

Some readers may think that the findings presented in Fig. 4 result largely from the small number of contributions employed for constructing the solid line. One advantage in having a large sample of contributions is the fact that the validity of this finding can be verified by use of other data. Figure 5 is based upon the contributions of an entirely different group of chemists. It presents data for 2295 contributions made by 192 chemists each of whom made at least one contribution that is cited and discussed in from 6 to 19 histories. Nevertheless, Fig. 5 reveals the same general trend as does Fig. 4. Here again the curve which shows the production rate for total output and that which shows the production rate for the least meritorious contributions tend to merge at the uppermost age level, and at the highest age level they coincide.

Figure 6 is based upon the work of chemists of less notable average accomplishment than those whose production rates are shown in Figs. 4 and 5. It sets forth data for 2453 contributions made by 528 chemists each of whom made at least one contribution that is cited in from 2 to 5 histories. Here again the two curves which represent production rates for total output and for least important contributions approach each other rapidly beyond age 39, and then coincide at the uppermost age level.

As compared with Figs. 4 and 5, the dot-dash line in Fig. 6 lies closer to the broken line at almost all ages. This results from the fact that a greater proportion of the total output of the contributors on whose work Fig. 6 is based was of relatively minor importance. This explains also why the solid line in Fig. 6 persists to a greater age level than do the solid lines in Figs. 4 and 5.

One reason why I chose to study contributions to the field of chemistry is the fact that this is a field that has been extensively worked. Therefore, large numbers of very superior contributions in this field are available for study. My master list includes all of the major chemists of whom we have any record. It includes contributors from every country that has produced any important workers in the field—that is, from far-off Australia, from Japan, China, India,

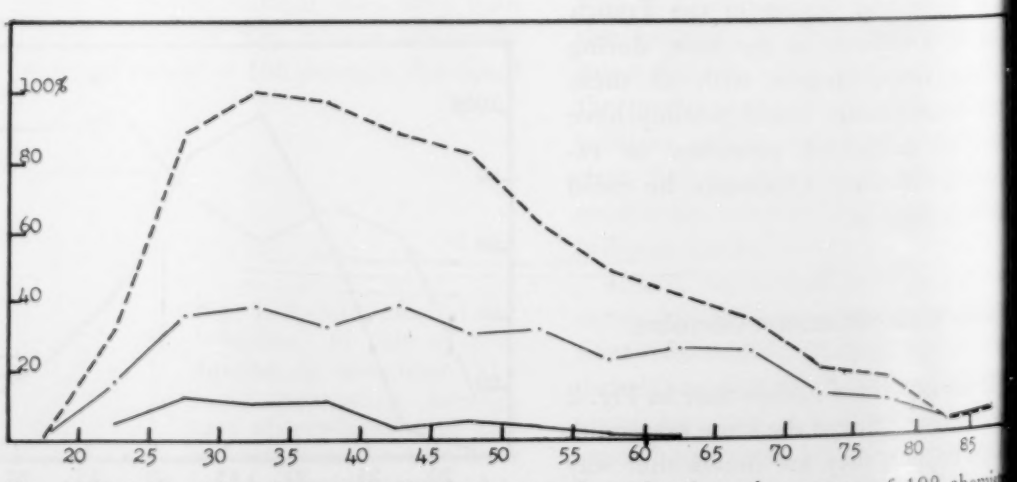

Fig. 5. Relationship of age (abscissa) to rate of production of a group of 192 chemists not covered in Figs. 1, 2, 3, and 4. The solid line represents average rate for "one best" contribution; the dot-dash line, for 1016 relatively minor contributions; the broken line for 2295 contributions that constitute the total output of this group, as revealed by a master list.

South America, and Ceylon, and from others too numerous to list. And my findings possess internal consistency. For example, in Fig. 7 the solid line shows median percentage values that were found by study of 23 histories of chemistry and the dot-dash line presents median percentage values that were obtained by study of 31 histories. Each of these two curves presents age data for chemists, now dead, who were born after 1775 and not less than 70 years prior to publication of each book from which information was obtained. The slightness of the difference in these two curves suggests that additional data would change the picture only slightly if at all.

Some who read this article may wish to follow it up by turning to my discussion of the relation between age and achievement in many other fields of science, as well as in such other areas as practical invention, literature, music, art, politics, business, statecraft, mathematics, prize-fighting, philosophy, and so on. I refer such readers to my book, *Age and Achievement* (*48*), which sets forth, by means of tables and graphs, a considerable amount of factual information analogous to that presented here. This book also sets forth 16 possible reasons for the early decrements in production rate that occur in some fields of endeavor. (*48*, pp. 328 ff.)

Recent events evidence the fact that man is rapidly attaining control over almost everything in the universe except himself. If he is to avoid destroying himself, man must learn quickly to exploit more fully than heretofore the powers that lie within his own mind. This is only one of several reasons why we never can know too much about the conditions that give rise to creative thinking of a very high order.

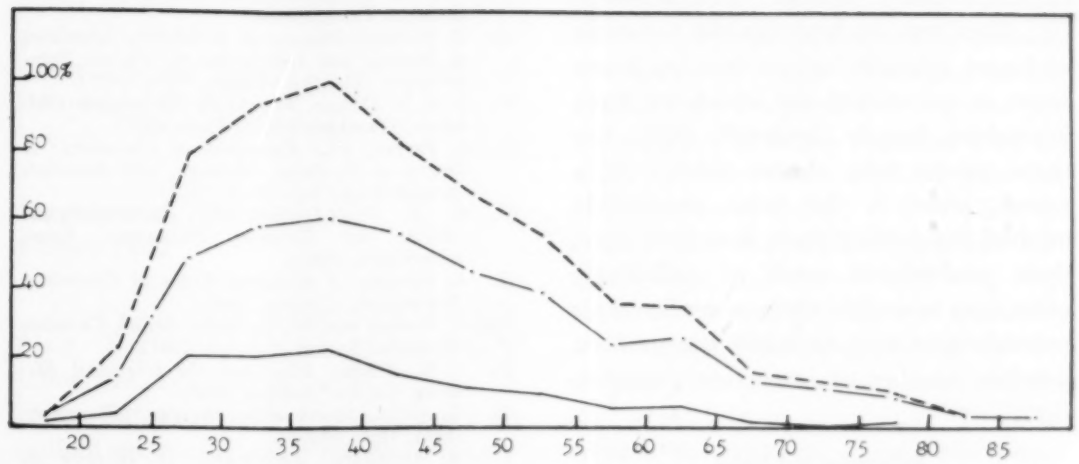

Fig. 6. Relationship of age (abscissa) to rate of production of a group of 528 chemists of less notable accomplishment than those covered in Figs. 1, 2, 3, 4, and 5. The solid line represents average rate for "one best" contribution; the dot-dash line, for 1667 relatively minor contributions; the broken line, for 2543 contributions that constitute the total output of this group, as revealed by a master list.

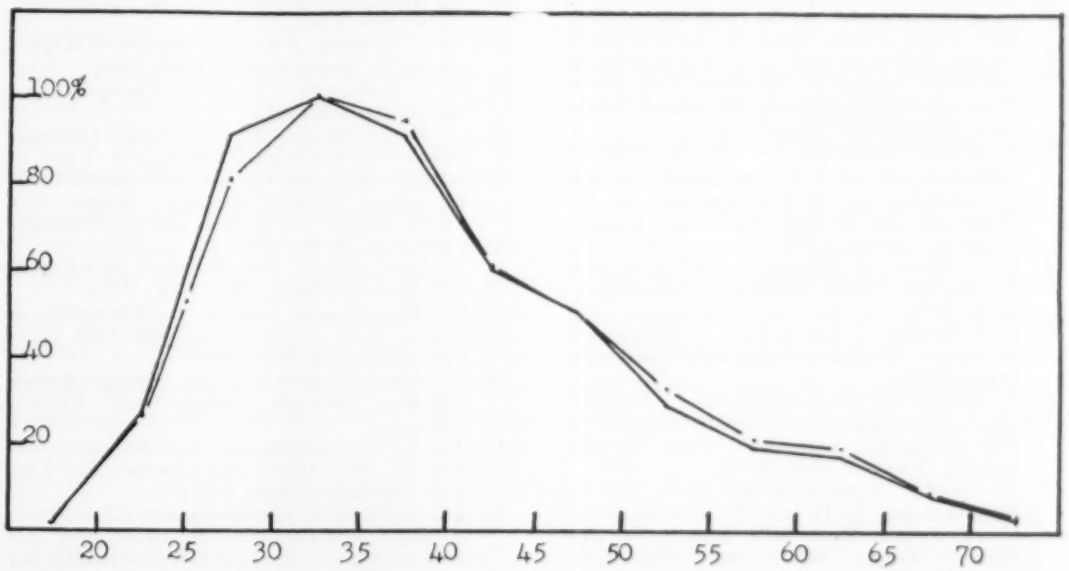

Fig. 7. Relationship of age (abscissa) to rate of production in chemistry. The solid line represents median percentage values based on data in 23 histories of chemistry; the dot-dash line, median percentage values based on data in 31 histories of chemistry.

Comment

How are the findings presented in this article to be interpreted? At present we are in no position to give an adequate explanation. Undoubtedly multiple causation operates in these complex behaviors and no condition as yet discovered is likely of itself to be a sufficient or necessary cause. Most psychologists believe, however, that few persons ever actually reach the very peak of performance of which they are capable. And, if most individuals fail to attain their potential peak performance, it is inconceivable that any entire age group has ever attained its peak. Since most individuals, and *all* age groups, are probably content to come to rest at some point below their maximum potential performance, these curves may reflect largely the relative extents to which the chemists within each of the several age groups have made an all-out effort to achieve. This is not to imply that the workers within any one age group have ever actually worked up to their full capacity but rather that the most productive group may have come closer to doing so than has any other group.

Since these curves represent only the production rates that chemists have realized at successive age levels, and not their *potential* production rates, the curves do not prove that there is a decrement in the potential ability of gifted chemists that corresponds to the decrements in the curves. Possibly the decrements result partly, even largely, from the fact that older chemists often have been less strongly motivated than have younger ones and that, as compared with members of the younger age groups, members of the older ones more often have found themselves (like Dumas) in circumstances much less favorable for eliciting their best potential effort to achieve. If the conditions under which older chemists do their creative work were made more favorable, their actual production rate for high-level contributions might well be much higher than it is and might also hold up better at the higher age levels than it has heretofore. Who knows!

Today there is much discussion about the major crisis existing in the United States because of the present and future shortage of scientific personnel. In view of this, and in view of the data presented in this article, serious consideration of the following questions is in order: (i) What are the most feasible methods for postponing the decrement in the production rate for the gifted

chemist's really brilliant contributions? (ii) How can we best tap the reservoir of latent scientific talent that we know exists in our society but which we have heretofore largely ignored? (iii) For those youths who choose science as a career, what is the most practicable method for getting them launched upon their professional work at sufficiently early ages to enable them to realize their potentialities and to make the greatest possible number of important contributions?

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46. An analogous situation exists in the field of sports where, for example, the champion golfer may continue to play at an amateur level for a longer time than he will play at a championship level.
47. Like the word *contribution*, the word *masterwork* refers to the total research output reported during any one year. Often the chemist received his maximum number of credits or tallies for a single discovery, but sometimes, as in the case of Sir Humphry Davy, the chemist made several highly important discoveries during the course of a single year.
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Future Radiation Dosage from Weapon Tests

Extrapolations are offered for three possibilities—testing remains constant, it ceases, it increases.

D. R. Inglis

The world-wide radioactive fallout from H-bomb tests has raised the question whether this change in environment will have serious consequences for the healthy development of man. As has been discussed by W. F. Libby, commissioner of the Atomic Energy Commission, the main constituents which the tests add to man's radioactive environment are strontium-90 and cesium-137 (*1–3*). The former appears to be of greater importance because its chemical similarity to calcium leads to its selective deposition in bone, where in sufficient quantity it may have carcinogenic effects. In spite of the present experimental uncertainties in predicting the biological effectiveness of Sr^{90} from the better-known effects of radium, there seems to be general agreement that the Sr^{90} level now attained as a result of past tests is not a real hazard, when judged on a global scale of normal human misery.

The serious question pertains to future tests and depends, of course, on the rate at which tests may be continued in the future. Many statements, some of them of a sort to placate fears, have been made about the effects to be expected as a result of past tests.

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The purpose of this article (*4*) is to extend the discussion to include the effects of future tests by making various assumptions about the course of future events. For the sake of extrapolating into the future, we shall assume that any one of three possible courses might be followed; and with these three we hope to bracket the likely actual development of future testing.

The three courses, idealized for simplicity of calculation, are (i) that testing continues at its present rate, (ii) that testing now ceases and we consider only the result of the radioactive burden already injected into the stratosphere, and (iii) that the rate of testing continues to increase at the average rate at which it has increased since late 1951. Unless there is a drastic change in the policies of various nations, it seems likely that the actual event will lie between (ii) and (iii), on the average, for many years. The expressions for the accumulated activities corresponding to these different assumptions are derived in the last section of the paper, where the equations referred to in other parts of the paper will be found. These equations are used as the basis for the following qualitative discussions.

Extent of Past Testing

W. F. Libby has given the figure of ½ mc/mi² per megaton for the distributed contamination by Sr^{90} from the explosion of a bomb—that is, an H-bomb of sufficient power to penetrate the stratosphere injects into it enough radioactivity of Sr^{90} that, if the activity should be distributed uniformly above (or on) the earth's surface, it would amount to one-half millicurie per square mile for each megaton (TNT equivalent) of that part of the bomb's power derived from fission. We can use this figure as a unit of bomb radioactivity effective for our purpose.

The most reliable figure available (*2*, p. 952) for the extent of past testing is that about 30 megatons equivalent of fission products had been deposited in the stratosphere by about the end of 1956. Libby also gives the mean life for fallout from the stratosphere as about 10 years, or perhaps a little less, and for radioactive decay of Sr^{90} it is 40 years (corresponding to half-lives of 7 years and 28 years, respectively). These are both longer than the period $T_0 = 5$ years over which tests have been carried out between late 1951 and late 1956, and we may reasonably calculate as though the injection had been at a constant rate equal to the average rate R_0 over this period, although the injection was actually strongly peaked at the middle of the period, in 1954.

Prediction of Effects of Future Tests

1) *Accumulated fallout from a single blast.* The basic problem from which others are compounded is the calculation of the fallout following a single burst of radioactive material into the stratosphere by a single thermonuclear test. Let a single blast introduce an amount A of radioactivity into the stratosphere at time $t = 0$, and assume that the stratospheric circulation distributes this material uniformly in a time that is negligible in comparison to the half-lives for fallout and radioactive decay, so that fallout and decay occur uniformly over the earth's surface (*5*). In this case the radioactive burden in the stratosphere decays both by fallout and by radioactive decay (in close analogy to a nuclide which may decay, for example, by either alpha or beta emission). The accumulated radioactivity y on the surface of the earth then builds up by fallout at a rate which depends on the stratospheric burden at any time t and on the decay constant for fallout, and it is diminished by radioactive decay at a rate depending on the amount y on the ground at this time and the radioactive decay constant. The net effect of these two competing processes at ground level is that, at first, when the fallout from the large stratospheric burden is high and there is still very little to decay on the ground, the amount y on the ground builds up; but as the rate of gain from fallout decreases and the rate of loss from radioactive decay increases, the graph of y versus t levels off at a maximum and thereafter decreases as shown by curve 0 of Fig. 1 (See Eq. 2 in the section "Mathematical considerations"). On the basis of Libby's figures cited above, y reaches a maximum value of $0.535A$ about 16 years after the blast.

2) *Result of continuing tests at a constant rate.* Although tests are actually conducted as a series of isolated events, their effect over a long period may be approximated satisfactorily by assuming an average rate of injection of radioactivity into the stratosphere. Let us therefore consider the effect of continuing H-bomb tests throughout the world at the same average rate R_0 at which they have been conducted over the past 5 years.

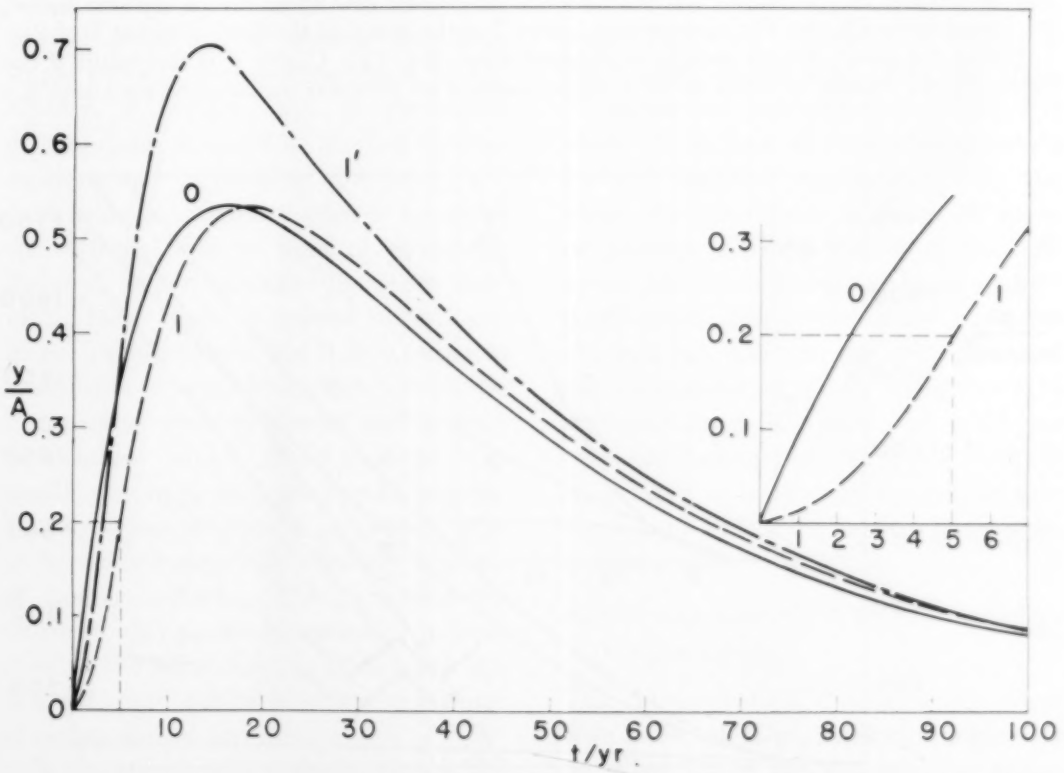

Fig. 1. Curve 0 gives the rise and fall of ground activity (Eq. 2) following a single burst (equal in magnitude to the total testing through 1956). The abscissa is time in years. Curve 1 gives the result (Eq. 12) for testing at a uniform rate, $R_0 = 3$ mc/mi² yr, over the first 5 years, after which testing is discontinued. The ground radioactivity in millicuries per square mile may be found by setting $A = 15$ mc/mi², corresponding to the estimated 30 megatons equivalent of fission products deposited in the stratosphere by the end of 1956. The peak value, $y = 8$ mc/mi², occurs after 16 years—that is, in 1972. This predicted peak is about 2.75 times as large as the calculated value of 2.95 mc/mi² at the end of 1956. Curve 1′ is the same as curve 1 except that it is computed on the assumption that the mean life for fallout is 5 years (instead of 10 years).

The stratospheric burden then builds up to a steady value for which the rate of attrition by fallout and radioactive decay is just balanced by the steady replacement from testing. This course of events, which is described by Eq. 8, is represented by curve 2 of Fig. 2. For the values we have adopted for the constants, y approaches asymptotically to the limiting value of 96 mc/mi². This limit is 32.6 times the intensity of radiation from fallout at the end of 5 years. The intensity reaches half of the limiting value in 36 years. For comparison, curve 1 on the same figure shows the result (Eq. 12) if tests had been stopped at the end of 1956. To show the effect of a change in the somewhat doubtful value of the mean life for fallout, curve 2′ shows the result when the mean life is assumed to be 5 years—a value favored by some workers in the field.

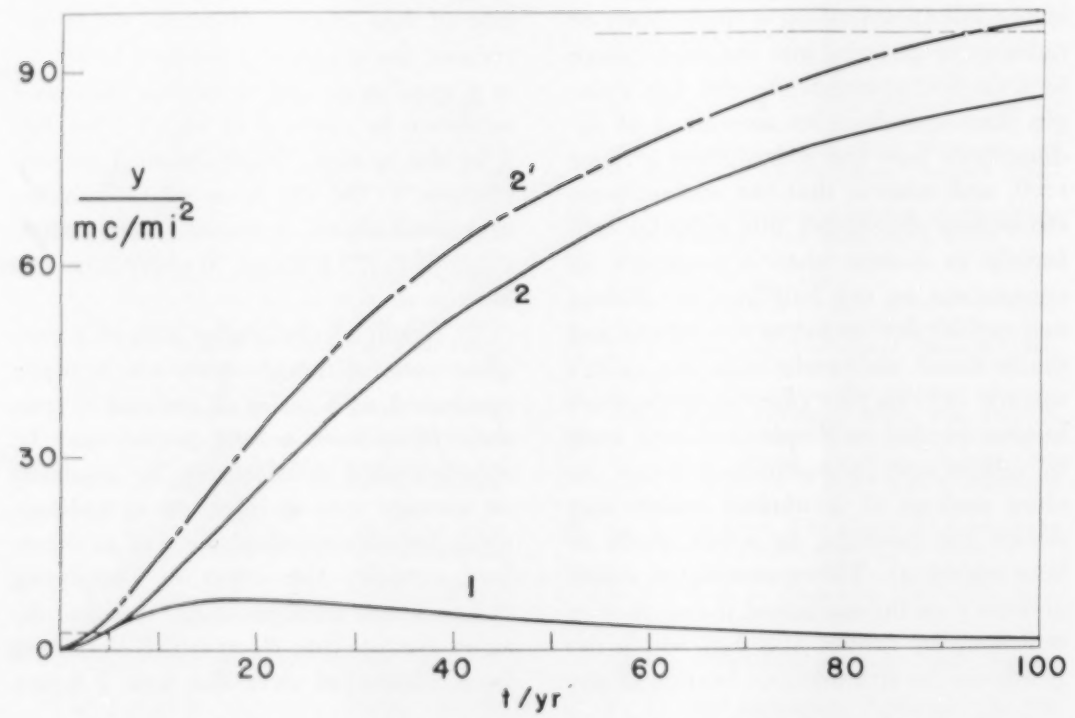

Fig. 2. Curve 2 gives the approach to equilibrium intensity of fallout (Eq. 8) for a steady rate of testing, $R_0 = 3$ mc/mi² yr. The horizontal broken line gives the asymptotic value, 96, found from Eq. 10. For comparison, curve 1 is the same as the broken curve 1 of Fig. 1, giving the result if tests should be stopped now (Eq. 12). Curve 2′ is the result if the mean life for fallout is taken to be 5 years (instead of 10 years as assumed for curve 2).

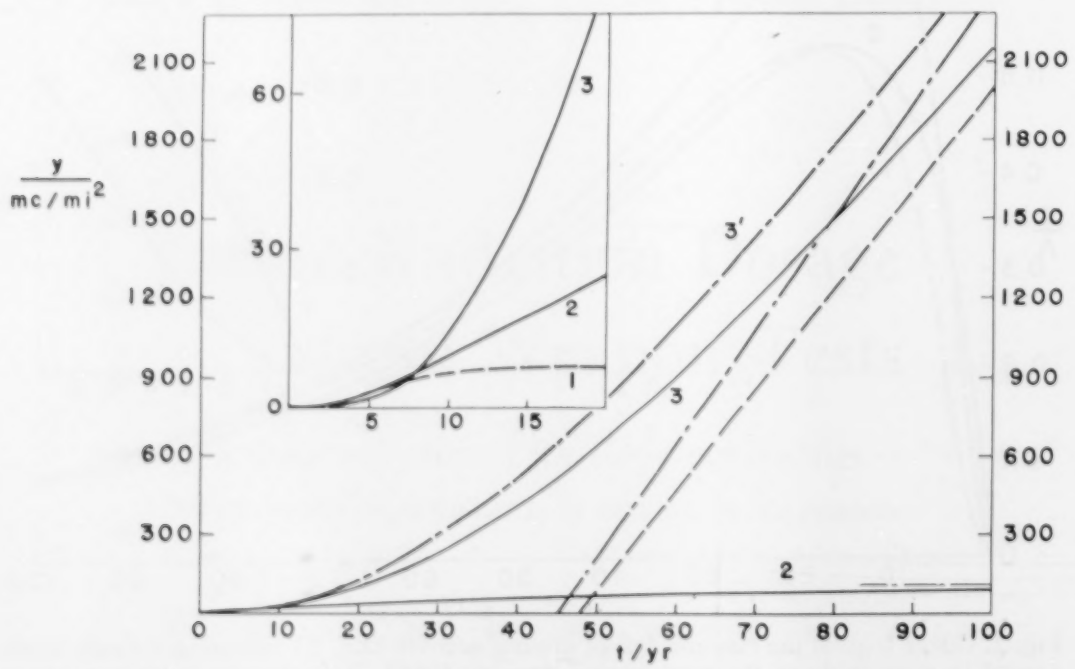

Fig. 3. Curve 3 gives the growth of fallout activity if the rate of testing increases in direct proportion to the time (Eq. 17). The dashed straight line on the right indicates the asymptotic value from Eq. 20. The ordinate gives ground radioactivity in millicuries per square mile. The insert shows detailed comparisons for the first few years. As in Fig. 2, curves 1 and 2 give the respective activities if tests should be discontinued or if they should continue at the present rate. The former is too low to be seen on the scale of the large graph. Curve 3′ and the dash-dotted straight line are the corresponding curve and asymptote if the mean life for fallout is assumed to be 5 years (instead of 10 years).

It should be noted that y is the accumulated amount of one particular radioactive nuclide. The numerical values given above apply to Sr^{90}, the most significant activity for the present discussion. The total amount of radioactivity would be the sum of such terms for all the radioactive materials involved.

3) *Future dosage if tests should be stopped now.* If testing proceeded at a constant rate up to time T_0 and then stopped abruptly, the radioactive material then on the ground would disintegrate according to the simple exponential law of radioactive decay, while the course of events for the material in the stratosphere at time T_0 would be the same as if this material had been injected by a blast at this instant.

This is described mathematically by Eqs. 11 and 12 and is shown graphically by curve 1 of Fig. 1. Except for the initial part, it differs very little from the result of a single large test carried out at time $T_0/2 = 2.5$ years, as is shown by the uniform lateral displacement between curves 0 and 1. [For the ordinate of curve 0, y/A is replaced by $(\lambda_f + \lambda_r)\, y/R_0$ to fit Eq. 12.] Curve 1′ is the same as curve 1 except that it is computed on the assumption that the mean life for fallout is 5 years (instead of 10 years).

4) *Future dosage if the rate of testing should continue to rise at a constant rate.* Unless special international arrangements are consummated, it is to be anticipated that there will be an increasing number of nations testing nuclear weapons in the future, and it is possible that tests by each country will grow in size or number, or both, as a result of the normal expansion of military requirements. As a plausible upper limit to the likely future world-wide testing, barring war, we assume a rate $R(t)$ which increases at a steady rate equal to the average rate of increase from the beginning of H-bomb testing up to the present. Equation 17 which describes this case, is quite complicated, but it predicts that, as is shown by curve 3 of Fig. 3, there is an accelerated increase of the accumulated radioactivity y on the ground, as should be expected. This curve asymptotically approaches the dashed straight line. With the constants adopted for this discussion, the radioactivity y on the ground eventually increases at a steady rate of 38.4 mc/mi² per year for this program. The results for the other assumed testing programs are included for comparison in this figure. Curve 3′ and the dash-dotted straight line are the corre-

sponding curve and asymptote if the mean life for fallout is assumed to be 5 years (instead of 10 years).

Discussion and Conclusion

From these calculations we can make several statements comparing future dosages with "present" dosages. If tests had been stopped at the end of 1956, the ground intensity of Sr^{90} would have increased by 1970 to a maximum about two and three-quarters times that at the end of 1956, and thereafter it would gradually decline (Fig. 1). If tests should continue at a steady average rate, the ground intensity would increase to a limiting value about 32.5 times as great as it was at the end of 1956 (Fig. 2). In the extreme case that the rate of testing should go on increasing at the steady rate equal to the average rate of increase during the first 5 years, the ground intensity in 100 years would be about 730 times as great as it was at the end of 1956 (Fig. 3). The last figure, of course, is intended only to supply a plausible upper limit based on an easily formulated assumption and to suggest that in the natural course of events a substantial increase is to be expected. It does not seem likely that peacetime testing will amount to such limits.

If we should attempt to provide a very rough calibration of the scale of dosage we have been using in terms of anticipated human pathology, we would pass beyond the realm of straightforward analysis and into a field of very necessary and vital speculation which is, however, beyond the proper scope of this paper. About it I shall here do no more than make a few very inadequate remarks. Some idea of the extent of the problem may be gained from Libby's papers (*1–3*) and their lists of references, though much work remains to be done on it.

Some perspective on the problem can be gained by comparison of the radioactivity from the tests with the radiation to which large populations are normally exposed. Libby has referred (*3*) to the variation of cosmic rays with altitude, pointing out that the variation of ionization in bone between Denver and New York is much greater than the bone radiation from Sr^{90} due to tests to date. A different approach is to compare Sr^{90} with another radioactive substance, namely radium, which also deposits in bone and which is very widely distributed in small and varying concentrations in drinking water. Radiological studies (*6*) show that the residents of the western suburbs of Chicago, who drink deep-well water containing about ten times as much radium as average drinking water, have an internal dose due to radium greater than the dose they would have from strontium if the surface density of Sr^{90} were 3000 mc/mi². Even with our most pessimistic assumption of a steadily increasing rate of testing, it would take about 125 years for the world-wide average density of Sr^{90} to reach this level.

In any such discussion, allowance must be made for fluctuations. There is considerable variation in the world-wide distribution of Sr^{90}, the north temperate latitudes receiving more than the rest of the world, particularly in the general vicinity of test sites where there is also the additional burden of local fallout of other substances. Moreover, the efficiency with which Sr^{90} is transferred to human beings exhibits large local variations associated with calcium deficiencies in some soils. Thus certain local populations may be jeopardized by Sr^{90} long before the global average seems impressive.

The use of a special population, such as the Chicago suburbanites, as a basis for calibration is very insensitive and can give no more than a rough upper limit, a feeling of assurance that the hazard is not serious compared with other normal hazards of living. It is based on the fact that no recognizably greater incidence of trouble has been found there than elsewhere. To be recognizable, it would have to be much greater—else it would be masked by fluctuations and incomplete diagnoses.

A more sensitive criterion is found in the extrapolation to man of pathology induced experimentally in other animals. Here there is serious uncertainty in the extrapolation, but it is possible to establish a reasonable expectation of the numbers of cases of cancer and genetic abnormality which, while perhaps very small compared with the world population in which they occur, represent nevertheless a lamentable absolute amount of human suffering. The fact that the cause of this particular trouble, in contrast to the other hazards of normal life, is a deliberate act of governments brings it under special scrutiny.

It is nevertheless important that the problem, and the possible solution of the problem, of continued testing be viewed in realistic perspective. Relative quantities are important here as elsewhere, even though deliberate incidence of human misery is involved. Judgment should not be unduly swayed by one prediction of human suffering if the alternative were to increase appreciably the likelihood of a much greater catastrophe. Modern global war would involve such vast tragic consequences to irreplaceable institutions as well as to life and health that its avoidance must be the transcendent consideration. Some (myself among them, as is apparent in other writings) believe that an agreement to stop tests on a world-wide basis would reduce the likelihood of war and should be sought for that reason. In this view, the reduction of the prospective radiation dosage may be viewed as an incidental but relatively minor bonus, a secondary incentive for arranging to stop the tests. It is the primary incentive that must be most seriously considered in weighing the various aspects of the security of the nation and the world. The above analysis, together with an adequate treatment of the problems of pathology here merely mentioned, might give the impression that the secondary incentive is not as urgent as it seems to some. Such an impression should not be permitted to obscure the forcefulness of the primary incentive for stopping tests, that of the prevention of war.

Mathematical Considerations

As stated in the section "Extent of past testing," the data used by Commissioner Libby are (i) the total testing in the 5 years ending with 1956 was about 30 megatons' equivalent of TNT; (ii) about ½ mc/mi² of radioactivity results from 1 megaton equivalent; (iii) the mean life for fallout is about 10 years, or perhaps a little less; and (iv) the mean life for radioactive decay of Sr^{90} is 40 years. Since the decay constants (λ_f and λ_r) are just the reciprocals of the corresponding mean lives, $\lambda_f = 0.10$ per year for fallout and $\lambda_r = 0.025$ per year for radioactive decay of Sr^{90}. If R_0 is taken to be the average rate of production of Sr^{90} from testing during the 5 years ending with 1956,

$$R_0 = (6 \text{ megaton/yr})\,(\tfrac{1}{2} \text{ mc/mi}^2 \text{ megaton}) = 3 \text{ mc/mi}^2 \text{ yr}.$$

The 5-year period during which these tests have taken place is represented by the time T_0 in the general discussions. For comparison, the curves with primed numbers were computed on the assumption that the mean life for fallout is 5 years, a value favored by some scientists; the corresponding decay constant is $\lambda_f = 0.20$ per year. The values given above have been substituted in the equations below to obtain the numerical re-

sults cited in the section "Prediction of effects of future tests."

1) *Accumulated fallout from a single blast.* Assume that at time $t = 0$ radioactivity of amount A of some particular nuclide (for example, Sr^{90}) is put into the stratosphere by a single blast. Let λ_r be its radioactive decay constant, the fraction of this nuclide which decays per unit time; and let λ_f be the effective decay constant associated with fallout. (A decay constant is the reciprocal of the corresponding mean life.) It is further assumed that this radioactivity becomes uniformly distributed above the earth before appreciable loss occurs by fallout and decay. If there were no radioactive decay, the activity remaining in the stratosphere after fallout had continued for time t would be

$$x_0(t) = Ae^{-\lambda_f t},$$

and the activity on (or near) the earth's surface would be

$$y_0(t) = A(1 - e^{-\lambda_f t}).$$

But since radioactive disintegration with decay constant λ_r proceeds simultaneously and independently, the actual activities in the stratosphere and on the ground will be less than these by the factor $e^{-\lambda_r t}$. Thus the activity remaining in the stratosphere at time t will be

$$x(t) = Ae^{-(\lambda_f + \lambda_r)t} \qquad (1)$$

and the net accumulation on the ground will be

$$y(t) = A(1 - e^{-\lambda_f t})e^{-\lambda_r t}. \qquad (2)$$

Curve 0 of Fig. 1 is a plot of Eq. 2.

These results can also be obtained by solving the differential equations obtained by noting that the instantaneous rate of fallout from the stratosphere to the ground is $\lambda_f x$ and the rates of loss by radioactive decay are $\lambda_r y$ in the stratosphere and $\lambda_r x$ on the ground; so

$$dx/dt = -\lambda_f x - \lambda_r x = -(\lambda_f + \lambda_r)x$$

and

$$dy/dt = +\lambda_f x - \lambda_r y$$

The results cited in subsection 1 of "Prediction of effects of future tests" were obtained from Eq. 2.

The resultant effect for a series of blasts is just the sum of terms similar to those in Eqs. 1 and 2, since the rate of decay of the radioactivity from each blast is independent of other events. Thus, if radioactivity of amount A_1 is injected into the stratosphere at time t_1, amount A_2 at time t_2, and so forth, then the radioactive burdens in the stratosphere and on the ground at any later time t are, respectively,

$$x(t) = A_1e^{-(\lambda_f + \lambda_r)(t-t_1)} + A_2e^{-(\lambda_f + \lambda_r)(t-t_2)} + \ldots \qquad (3)$$

$$y(t) = A_1[1 - e^{-\lambda_f(t-t_1)}]e^{-\lambda_r(t-t_1)} + A_2[1 - e^{-\lambda_f(t-t_2)}]e^{-\lambda_r(t-t_2)} + \ldots \qquad (4)$$

The sums should include only the terms for those blasts that have taken place prior to time t in order to avoid the absurdity of including effects of blasts before the blasts have taken place.

2) *Result of continuing tests at a constant rate.* One easily calculated special case of continued testing is that in which radioactive material is produced at a constant rate R_0. In this case, the A of Eqs. 1 to 4 is replaced by $R_0\,dt_i$, the amount of the material produced between t_i and $(t_i + dt_i)$. This program offers a fairly good approximation to a continued sequence of blasts at a constant average rate, if the time between the blasts is smaller than the half-lives for fallout and radioactive decay. Under these assumptions, the sums in Eqs. 3 and 4 become the integrals

$$x(t) = \int_0^t R_0e^{-(\lambda_f + \lambda_r)(t-t_i)}dt_i. \qquad (5)$$

and

$$y(t) = \int_0^t R_0[1 - e^{-\lambda_f(t-t_i)}]e^{-\lambda_r(t-t_i)}dt_i. \qquad (6)$$

Straightforward evaluation of these integrals leads to

$$x(t) = \frac{R_0}{(\lambda_f + \lambda_r)}[1 - e^{-(\lambda_f + \lambda_r)t}] \qquad (7)$$

and

$$y(t) = \frac{R_0}{(\lambda_f + \lambda_r)} \times \left[\frac{\lambda_f}{\lambda_r} + e^{-(\lambda_f + \lambda_r)t} - \left(\frac{\lambda_f}{\lambda_r} + 1\right)e^{-\lambda_r t}\right] \qquad (8)$$

These asymptotically approach the limiting values

$$x_\infty = R_0/(\lambda_f + \lambda_r) \qquad (9)$$

$$y_\infty = R_0\lambda_f/\lambda_r(\lambda_f + \lambda_r) \qquad (10)$$

The numerical results cited in subsection 2 of "Prediction of effects of future tests" were obtained from Eqs. 8 and 10. Curve 2 of Fig. 2 is a plot of Eq. 8, and the broken horizontal line corresponds to Eq. 10.

The value of the mean life for fallout is not well established, and any revision in it would probably be downward. As an illustration of the alteration of the graphs in consequence of such a change, take the mean life to be 7 years (instead of 10 years). The value of y (5 yr) then becomes 3.95 mc/mi² (raised from 2.95), and the asympto value $y(\infty)$ is raised proportionate less, from 2 to 102.1 mc/mi². The r tio $y(\infty)/y$ yr) is lowered from 32. to 25.9.

3) *Future dosage if ts were to b stopped now.* Assume at testing pro duces the radioactive material at constant rate R_0 up t time T_0, wh testing is discontinue abruptly. F $0 \leq t \leq T_0$, Eqs. 7 an 8 still appl Hence the amounts of material in th stratosphere and on the ground at tim T_0 are, respectively,

$$x(T_0) = \frac{R_0}{(\lambda_f + \lambda_r)}[1 - e^{-(\lambda_f + \lambda_r)T_0}]$$

and

$$y(T) = \frac{R_0}{(\lambda_f + \lambda_r)} \times \left[\frac{\lambda_f}{\lambda_r} + e^{-(\lambda_f + \lambda_r)T_0} - \left(\frac{\lambda_f}{\lambda_r} + 1\right)e^{-\lambda_r T_0}\right]$$

As pointed out in subsection 3 of "Pre diction of effects of future tests," th course of events for the material in th stratosphere at time T_0 is the same a if it were injected by a single blast a that instant—that is, $x(t)$ for the pre ent case is obtained by replacing A b $x(T_0)$ and t by $(t - T_0)$ in Eq. 1. Th the stratospheric burden at any tim $t > T_0$ is

$$x(t) = \frac{R_0}{(\lambda_f + \lambda_r)} \times [1 - e^{-(\lambda_f + \lambda_r)T_0}]\, e^{-(\lambda_f + \lambda_r)(t-T_0)}$$

whence

$$x(t) = \frac{R_0}{(\lambda_f + \lambda_r)} \times [e^{(\lambda_f + \lambda_r)T_0} - 1]e^{-(\lambda_f + \lambda_r)t}. \qquad (11)$$

The amount of radioactivity on th ground is expressible as the sum of tw terms. The first term y_1 represents th residue after the amount $y(T_0)$ whic was on the ground at time T_0 has un dergone exponential radioactive decay until time t. This term is, therefore,

$$y_1 = y(T_0)e^{-\lambda_r(t-T_0)} = \frac{R_0}{(\lambda_f + \lambda_r)}\left[\frac{\lambda_f}{\lambda_r} + e^{-(\lambda_f + \lambda_r)T_0} - \left(\frac{\lambda_f}{\lambda_r} + 1\right)e^{-\lambda_r T_0}\right]e^{-\lambda_r(t-T_0)}$$

$$= \frac{R_0}{(\lambda_f + \lambda_r)}\left[\frac{\lambda_f}{\lambda_r}e^{\lambda_r T_0} + e^{-\lambda_f T_0} - \left(\frac{\lambda_f}{\lambda_r} + 1\right)\right]e^{-\lambda_r t}$$

The additional radioactivity on th ground as a result of fallout from th stratosphere is found by the same metho as was used to get $x(t)$—that is, A is re placed by $x(T_0)$ and t by $(t - T_0)$ Eq. 2. Hence, the second portion y_2 the radioactivity on the ground at an time $t > T_0$ is

$$y_2 = x(T_0)(1 - e^{-\lambda_f(t-T_0)})e^{-\lambda_r(t-T_0)}$$

$$= \frac{R_0}{(\lambda_f+\lambda_r)}[1 - e^{-(\lambda_f+\lambda_r)T_0}] \times (1 - e^{-\lambda_f(t-T_0)})e^{-\lambda_r(t-T_0)}$$

$$= \frac{R_0}{(\lambda_f+\lambda_r)}\left\{[e^{\lambda_r T_0} - e^{-\lambda_f T_0}]e^{-\lambda_r t} + [1 - e^{(\lambda_f+\lambda_r)T_0}]\, e^{-(\lambda_f+\lambda_r)t}\right\}$$

Hence the total amount of radioactivity on the ground at time $t > T_0$ is

$$y(t) = y_1 + y_2$$

$$= \frac{R_0}{(\lambda_f+\lambda_r)}\left\{\left[\frac{\lambda_f}{\lambda_r}e^{\lambda_r T_0} + e^{-\lambda_f T_0} - \left(\frac{\lambda_f}{\lambda_r}+1\right)\right]e^{-\lambda_r t} + [e^{\lambda_r T_0} - e^{-\lambda_f T_0}] \times e^{-\lambda_r t} + [1 - e^{(\lambda_f+\lambda_r)T_0}]\, e^{-(\lambda_f+\lambda_r)t}\right\}$$

$$y(t) = \frac{R_0}{(\lambda_f+\lambda_r)}\left\{\left(\frac{\lambda_f}{\lambda_r}+1\right)[e^{\lambda_r T_0} - 1]e^{-\lambda_r t} - [e^{(\lambda_f+\lambda_r)T_0} - 1]\, e^{-(\lambda_f+\lambda_r)t}\right\} \quad (12)$$

This equation is plotted as curve 1 of Fig. 1.

(4) *Future dosage if rate of testing should continue to rise at a constant rate.* The idealized case which is selected as a plausible upper limit to the likely future world-wide testing is taken to be that in which $R(t)$, the rate of production of radioactive materials, increases in direct proportion to the time t. Then if R_0 is the average rate of production during the interval from $t=0$ to $t=T_0$, the rate at any time t is

$$R(t) = (2R_0/T_0)t \quad (13)$$

and the material produced in the interval between t_i and $(t_i + dt_i)$ is

$$(2R_0/T_0)t_i \cdot dt_i.$$

When this replaces A in Eqs. 3 and 4 and the sums are replaced by integrals over the time t_i, the result is

$$x(t) = \int_0^t (2R_0/T_0)t_i e^{-(\lambda_f+\lambda_r)(t-t_i)}dt_i \quad (14)$$

$$y(t) = \int_0^t (2R_0/T_0)t_i \times [1 - e^{-\lambda_f(t-t_i)}]e^{-\lambda_r(t-t_i)}dt_i \quad (15)$$

Hence

$$x(t) = \frac{2R_0}{T_0(\lambda_f+\lambda_r)^2} \times [(\lambda_f+\lambda_r)t - 1 + e^{-(\lambda_f+\lambda_r)t}] \quad (16)$$

$$y(t) = \frac{2R_0}{T_0}\left[\frac{\lambda_r t - 1 + e^{-\lambda_r t}}{\lambda_r^2} - \frac{(\lambda_f+\lambda_r)t - 1 + e^{-(\lambda_f+\lambda_r)t}}{(\lambda_f+\lambda_r)^2}\right]$$

$$= \frac{2R_0\lambda_f}{T_0\lambda_r(\lambda_f+\lambda_r)} \times \left[t - \left(\frac{1}{\lambda_r} + \frac{1}{(\lambda_f+\lambda_r)}\right) + \left(\frac{1}{\lambda_f} + \frac{1}{\lambda_r}\right)e^{-\lambda_r t} + \left(\frac{1}{(\lambda_f+\lambda_r)} - \frac{1}{\lambda_f}\right)e^{-(\lambda_f+\lambda_r)t}\right] \quad (17)$$

The latter result, which is shown as curve 3 of Fig. 3, is expressed somewhat more neatly if the decay constants λ_f, λ_r and $(\lambda_f+\lambda_r)$ are replaced by the corresponding mean lives τ_f, τ_r, and τ_t.

For late times, for which $t \gg 1/\lambda_r$, the exponentials in Eqs. 16 and 17 approach zero, so $x(t)$ and $y(t)$ approach the asymptotic values

$$x = \frac{2R_0}{T_0(\lambda_f+\lambda_r)}\left[t - \frac{1}{(\lambda_f+\lambda_r)}\right] \quad (18)$$

$$y = \frac{2R_0\lambda_f}{T_0\lambda_r(\lambda_f+\lambda_r)}\left\{t - \left[\frac{1}{\lambda_r} + \frac{1}{(\lambda_f+\lambda_r)}\right]\right\} \quad (19)$$

With the assumed numerical values for the constants, Eq. 19 becomes

$$y = (38.4\ \text{mc/mi}^2)\,(t/\text{yr} - 48). \quad (20)$$

This asymptote is shown as the dashed straight line at the right in Fig. 3.

This assumption of a steadily increasing rate of testing is not, of course, the best possible approximation to the course of events over the past few years. However, refinements in the assumptions for this period have little significance because the effects of these early tests are overshadowed at much later times by the large amounts of activity resulting from the assumed accelerated rate of testing.

References and Notes

1. AEC release, 12 Oct. 1956; W. F. Libby, *Proc. Natl. Acad. Sci. U.S.* 42, 365 (1956).
2. W. F. Libby, *Proc. Natl. Acad. Sci. U.S.* 42, 945 (1956).
3. AEC release, Apr. 1957.
4. This work was performed, under the auspices of the U.S. Atomic Energy Commission, mainly in late 1956, which is the closing date for the data used in the examples. I am grateful to Dr. W. F. Libby, Dr. J. E. Rose, Dr. F. E. Throw, and Dr. L. A. Turner for discussion and suggestions. The order of presentation in the text and the "primed" curves on the graphs were kindly arranged by Dr. Throw.
5. Note that these calculations take no account of the radioactivity introduced directly into the troposphere, especially by fission explosions. Actually, in the Northern Hemisphere, tropospheric fallout constitutes a large fraction of the total, so the stratospheric burdens estimated in this paper are probably too high. Moreover, the biological effectiveness of fallout depends significantly on such factors as its precipitation as an insoluble salt and its redistribution in depth because of soil movements. [See W. F. Libby, *Proc. Natl. Acad. Sci., U.S.* 43, 758 (1957).] Such effects would change the numerical values for the stratospheric component of fallout without altering the general course of events. If certain scientists are correct in believing that horizontal mixing in the stratosphere is not very rapid (for example, L. Machta, "Hearings before the Joint Committee on Atomic Energy on the Nature of Radioactive Fallout and Its Effects on Man," May 27–June 3, 1957), the fallout over the earth's surface will be more or less nonuniform.
6. A. F. Stehney and H. F. Lucas, Jr., *Acta Radiol.* 43, 43 (1955); Geneva Conference, vol. 8, p. 852 (1955). Reference is also made to a forthcoming article by J. E. Rose. I am indebted to Dr. Rose for this and related information which suggested these calculations.

Irving Langmuir, Man of Many Interests

In these days of near hysteria on the world-wide scene, as claims and counterclaims are made of the superiority of this or that method of teaching science, of conducting scientific research, and of supporting basic research studies, it would do everyone involved in this turmoil a lot of good if he would pause a moment to consider Irving Langmuir's life, background and attitude toward science [V. J. Schaefer, "Irving Langmuir, Versatile Scientist," *Bull. Am. Meteorol. Soc.* **38**, 483 (1957); "In Memoriam: Irving Langmuir—Scientist," *J. Colloid Sci.* **13**, 3 (1958)]. With his death, on 16 August 1957, the world lost another of the scientific giants who strode across the scientific scene during the first half of the 20th century, leaving a trail of pioneering achievements which those with pessimistic attitudes attempt to explain away as "due to that period being the golden age of science when scientific breakthroughs were easier to come by, because there was so much virgin field to till."

Langmuir's attitude toward the modern scientific scene of the past few years was in direct conflict with such a philosophy. His enthusiasm for the newer achievements remained undiminished, his impatience being directed only toward those he felt were "dragging their feet" and serving as "wet blankets" in the development of new concepts and ideas.

Irving Langmuir on the slopes of Mt. Washington, New Hampshire, on Easter Sunday, 1944.

His research procedures and philosophy were in direct conflict with some of the current attitudes of industrialists and even research directors, who give voice to the idea that the day of the individualist and the "paper-clip, string, and sealing-wax" type of experiment as a basis of scientific achievement is of a bygone era, and that what are needed nowadays are teams of workers using only the most elaborate, expensive, and refined equipment if any degree of progress is to be expected in pushing back the frontiers of scientific knowledge.

It is quite possible that these attitudes have led us into our current predicament. Teamwork is needed for applied research and, in some cases, in operating the great cyclotrons, accelerators, radio telescopes, and satellite launchers whose end result may be the development of new ideas. In the final analysis, however, it is the dreamer, the isolated individual, or the individualist of a research organization who is responsible for the new concept, the radical approach, or the new theory which needs testing.

Langmuir gave wonderful talks on serendipity, which he often discussed with students. I have heard him hold forth at considerable length on the importance of developing an inquiring mind and an active interest in all natural sciences and, when working on a research problem, of trying everything—even the things which apparently will obviously not work! By ranging far and wide in exploring the problem at hand, he stressed the importance of awareness at all times, since it is often at times least expected that the unexpected—the fortunate accident—happens.

Langmuir's concepts of the scientist and his role in society were firm and definite. They were well expressed in his presidential address before the American Association for the Advancement of Science entitled "Science, common sense and decency" [*Science* **97**, 1 (1943)]. He believed that there were some aspects of

the world to which the scientific method was not applicable in commonly accepted framework. The ideas were developed in a talk delivered before the National Academy of Sciences when the new General Electric Research Laboratory was dedicated, and dealt with convergent and divergent phenomena.

It was his conviction that this receptiveness to the unexpected is one of the most important attributes to cultivate if a young student is to become a successful scientist.

Some of his attitudes were undoubtedly acquired from his boss—the beloved and lately deceased Willis R. Whitney. It was "Doc" Whitney who popularized the word *serendipity* and whose daily greeting of "Are you having fun?" and "Have you *tried* it?" undoubtedly served to develop Langmuir's enthusiastic attitude toward his coworkers. It was also Whitney who, when told by the then recently employed Langmuir that he was having a wonderful time but couldn't see how anything he was doing could help the company, retorted that this was *his* (Whitney's) worry, not Langmuir's.

In these days of empire building, conformity, and the organization man, in which the nonconformist, an unorthodox thinker, or an individualist is likely to encounter increased difficulty in finding an environment conducive to living, let alone in carrying out effective research, we should examine the environment which permitted the development of Whitney, Coolidge, Dushman, Hull, and Langmuir. I was privileged to know these men and to be familiar with the environment in which they flourished. It was one permeated with free communication, enthusiastic response to each other's achievements, and sincere helpfulness toward each other's problems. In some respects, the industrial laboratory in which Langmuir spent most of his productive life was an environment perhaps superior to the best universities, since technicians were readily available to cope with problems of fabricating instruments and apparatus, while the new discovery which had practical application could often be followed to its ultimate use. Thus, in addition to enjoying discovery for its own sake, it was often possible to sense the full savor of achievement.

Langmuir's career demonstrates the value of a broad technical education and the importance of presenting intellectual challenges to youngsters at an early age.

I have seen him demonstrate the workings of a slide rule to grammar school students and offer the challenge

of underwater swimming and other equally difficult challenges, physical and mental, to pre-school youngsters.

He was never happier than when surrounded with youngsters and delighted in getting them to stretch their brains. We need more men like him, and we should devise workable procedures to take advantage of their enthusiastic help wherever programs are under development for leading bright youngsters toward scientific careers. Too little stress has been directed toward drawing the attention of youngsters to the satisfying sense of intellectual achievement which is an integral part of the compensations received by the true scientist. For those who feel that the golden age is past, Langmuir would probably say that it is certainly past for individuals who think this to be true. For the youngsters and the young of heart, he would say that there is no better time than the present, and I am sure he would demonstrate, with many illustrations, the opportunities which abound in all directions for those who have the will to do.

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News of Science

Euratom Agreement

John W. Finney reported in the 8 May *New York Times* that the United States and the European Atomic Energy Community have agreed in principle on a broad-scale cooperative program to promote the development of atomic power in Western Europe. The agreement, which still must be formally approved by both sides, provides for United States technical and financial assistance in the construction of atomic power plants in the six European nations banded together in the atomic energy group known as Euratom. When carried out, the agreement will represent one of the biggest steps yet taken by the United States to implement the policy of atoms-for-peace first proclaimed by President Eisenhower in 1953.

Inspection Issue Solved. In reaching the agreement, the two sides finally succeeded in overcoming the issue of inspection, which had obstructed negotiations in recent months. Previously, Euratom has been insistent that it should perform the inspection to make sure that none of the fissionable materials were diverted to military purposes. The United States, through the Atomic Energy Commission and the State Department, had been demanding inspection rights of its own as a precondition to cooperation.

In the recent negotiations a compromise agreement was reached. The details have not been made public, partly because the issue may still be subject to diplomatic negotiations. The negotiating teams were headed by Max Kohnstamm, special adviser to the Euratom commission, and R. W. Cook, deputy general manager of the Atomic Energy Commission.

Isotope of Element 102

Scientists in the University of California Radiation Laboratory have announced the definite discovery of an isotope of element 102. At the same time they said that in repeated, careful experiments they have been unable to duplicate the work of an international team of scientists who last year reported discovering an isotope of element 102.

The Berkeley research was reported on 5 May in Gatlinburg, Tenn., at a Conference on Reactions between Complex Nuclei, by Albert Ghiorso, a senior nuclear scientist in the Radiation Laboratory. The work was done by Ghiorso, Torbjorn Sikkeland, an exchange scientist from the Joint Establishment for Nuclear Energy Research at Kjeller, Norway; John R. Walton, research chemist; and Glenn T. Seaborg, Nobel laureate and professor of chemistry on the Berkeley campus.

Final identification of the element 102 isotope was achieved early in the morning of April 18, after a sustained 24-hour period of research, climaxing 3 months of experimentation. The element 102 isotope was created by bombarding a rare isotope (mass number 246) of curium (element 96) with carbon-12 nuclei having an energy of 68 million electron volts or carbon-13 nuclei of 75 mev. The new element 102 isotope has a mass number of 254; it decays quickly. Its half-life is 3 seconds. It decays by emitting an alpha particle and turning into fermium-250 (an isotope of element 100). As many as 40 atoms were observed in a single experiment.

The discovery was made by radically new methods of research. As yet the element 102 isotope has not been directly observed—chiefly because of its short half-life. The observations were made on fermium-250, the daughter atom, which has a half-life of 30 minutes. Under the conditions of the experiments, the scientists could deduce that the fermium atoms could arise only from the decay of the isotope of element 102.

In their experiments, the Berkeley scientists deposited curium over an area of less than a square centimeter on a thin nickel foil. This target foil was placed in front of the highly concentrated beam of the heavy ion linear accelerator. The target was enclosed in a container filled with helium gas.

When a curium atom captured a carbon nucleus, a new nucleus was instantaneously formed, four neutrons came off, and the resulting nucleus flew out of the target. This nucleus was slowed down by colliding with the helium atoms, and attracted to a metallic conveyor belt having a negative charge and moving just under the target. The belt passed next to a thin foil plate which had a strong negative charge. As the 102 atoms decayed by emitting an alpha particle, the resulting fermium atoms were kicked off the conveyor belt and attracted to the foil.

The length of foil was cut into five strips, and each was simultaneously analyzed in counters. The distribution of fermium atoms on the foil strips determined the half-life (the fast decay of the atoms of element 102 insured that most of the daughter fermium atoms were deposited on the closest sections of foil to the target, and fewer of them with greater distance). When the speed of the belt was changed, the distribution of fermium atoms varied in conformance with a 3-second half-life for the 102 isotope.

Identification of the atomic number of the element was made by chemically identifying the daughter atoms as fermium in chemical separation experiments with the dissolved foil.

The scientists searched repeatedly for evidence of an isotope of element 102 reported found last year by scientists of the Argonne National Laboratory in Chicago, the Harwell Laboratory in England, and the Nobel Institute in Stockholm, Sweden. These scientists re-

ported observing directly an isotope of element 102 with a half-life of 10 minutes and emitting alpha particles of 8.5 Mev. They bombarded curium 244 with carbon 13 nuclei in the Stockholm cyclotron. The energy range of the carbon nuclei was from 80 to 100 Mev and averaged 90 Mev. Working under very difficult conditions, the international group said they observed small amounts of element 102 activity in 12 out of 50 bombardments.

Ghiorso said the Berkeley group had attempted to duplicate this reaction, with a curium target of the same composition. Their beam of bombarding carbon nuclei was about 10 times as intense. They made many attempts to produce the reported activity, using beams of particles of 90 Mev and also particles varying over a wide energy range (60 to 100 Mev). All of the efforts were unsuccessful.

Academy Oceanography Committee

The National Academy of Sciences–National Research Council has formed a Committee on Oceanography whose primary purpose is to promote the future development of oceanography in the United States. The committee is sponsored by the Office of Naval Research, the Atomic Energy Commission, and the U.S. Fish and Wildlife Service. Harrison Brown of California Institute of Technology is chairman.

The committee has organized six panels to examine particular areas: the Panel on New Research Ships, Columbus Iselin, chairman; the Panel on New Devices for Exploring the Ocean, Allyn Vine, chairman; the Panel on Radioactive Waste Disposal at Sea, Roger Revelle, chairman; the Panel on International Cooperation in the Marine Sciences, Athelstan Spilhaus, chairman; the Panel on Ocean Resources, Robert Snider, chairman; and the Panel on Basic Research in the Marine Sciences, Alfred Redfield, chairman.

The committee is attempting, with the assistance of the panels (i) to formulate recommendations concerning a long-range national policy with respect to oceanography; (ii) to assist in all possible ways in increasing both the quantity and quality of basic research in the marine sciences; and (iii) to advise specific government agencies concerning those problems which involve the marine sciences. It is attempting to produce a preliminary report sometime during the summer.

The committee would welcome comments and critical examination of its activities. Interested persons should write to the chairman; the executive secretary, Richard C. Vetter; or to any one of the panel chairmen. The committee intends to keep marine scientists informed of its progress.

Pastore-Durham Bill Opposed

The national council of the Federation of American Scientists has released a statement opposing the Pastore-Durham Bill (S 3474 and HR 11926), which was introduced in Congress to facilitate the cooperation of the United States with certain of its allies in the field of atomic weapons. The FAS Council questions whether the proposed bill will contribute to the security of the United States, saying:

"It is generally recognized that an atomic stalemate now exists in the sense that total war would, in all likelihood, result in the destruction of all major powers engaged in such a war. . . . It would appear to be obvious that the greater number of nations coming into possession of atomic weapons, the more precarious becomes the stalemate. . . .

"We believe that the Congress and therefore the people should not delegate their responsibility in such matters to the administration. We feel that the U.S. should negotiate with other nations individual agreements concerning the transfer of nuclear weapons material and the exchange of restricted data; this can be done under the existing regulations of Section 121 of the Atomic Energy Act of 1954. These regulations require positive action of Congress as well as action of the Administration. We are strongly opposed to the Pastore-Durham bill which would, in effect, permit the Administration to make such arrangements without debate. It seems to use that the passage of this bill would be an irrevocable step which is likely to jeopardize our long-range goal of true security through worldwide, enforced disarmament.

Soviet Education Survey

The U.S. Department of Health, Education, and Welfare has announced that a survey of education inside the Soviet Union, the first Government-sponsored study of this kind, is being made by a team of 10 United States educators. The study team, headed by U.S. Commissioner of Education Lawrence G. Derthick, left for the U.S.S.R. on 6 May and will return around 10 June.

The survey has been made possible by the agreement of 27 January 1958 between the governments of the United States and the U.S.S.R. on exchange of missions in cultural, technical, and educational fields. Several technical and cultural missions have been exchanged, but this is the first time that an official group from America representing a cross-section of education will have visited the Soviet Union to observe various aspects of Soviet education. A group of Soviet educators will make a similar study of education in the United States at a later date.

In addition to Derthick, the team includes: Herold C. Hunt, Eliot professor of education, Harvard University, and former Under Secretary of Health, Education, and Welfare; Harry C. Kelly, assistant director for scientific personnel and education, National Science Foundation; A. John Holden, Jr., State Commissioner of Education, Vermont; Henry Chauncey, president, Educational Testing Service; George Z. F. Bereday, associate professor of education, Columbia University; and four members of the U.S. Office of Education staff, John R. Ludington of the Secondary Schools Section, Lane C. Ash, of the Division of Vocational Education, John B. Whitelaw of the Teacher Education Section, and Helen K. Mackintosh of the Elementary Schools Section.

BCG Vaccination

After weighing the advantages and disadvantages of BCG (*bacille Calmette-Guérin*) vaccination, an ad hoc committee of the Surgeon General of the United States reported recently that: "It is believed that the advantages of vaccination outweigh the disadvantages for tuberculin negative persons who are exposed to a definite risk of infection, especially if they cannot be retested frequently with tuberculin." The committee recommended BCG vaccination for those groups named by the American Trudeau Society, the American College of Chest Physicians, the American Medical Association, and the Medical Advisory Committee of Research Foundation.

The American Trudeau Society list of groups includes: (i) doctors, medical students, and nurses who are exposed to tuberculosis; (ii) all hospital and laboratory personnel whose work exposes them to contact with the bacillus of tuberculosis; (iii) individuals who are unavoidably exposed to infectious tuberculosis in the home; (iv) patients and employees in mental hospitals, prisons, and other custodial institutions in which the incidence of tuberculosis is known to be high; and (v) children and certain adults considered to have inferior resistance and living in communities in which the tuberculosis mortality rate is unusually high.

The vaccine may be obtained by any licensed physician in the United States and its territories by writing to the Research Foundation, 70 W. Hubbard St.,

Chicago 10, Ill. The Research Foundation and the University of Illinois are the only institutions licensed to produce and distribute CG in this country.

Government-University Relationships

The National Science Foundation released a report last month on *Government-University Relationships in Federally Sponsored Scientific Research and Development* that urges increased Federal support of basic research at colleges and universities and emphasizes the need for continuity of support in the interests of effective conduct of basic research. The report noted that Federal contracting and grant procedures could be simplified with reference to research and development contracting with institutions of higher learning and other organizations of a nonprofit character. It emphasized the need for Federal grant and contracting officers to be continually alert for ways and means to avoid needless procedural steps or other delays in negotiation, review, and payment of research contracts and grants.

Among the recommendations in the report are the following:

1) Problems of Government–university relationships in the Federal support of research at colleges and universities should be explicitly and completely dissociated from the budgetary needs and crises of the institutions and from the general issue of Federal aid to higher education.

2) Continuity of support is unanimously agreed to be essential for the effective conduct of basic research. To this end, it should be the general practice for Federal agencies to make grants and contracts for more than 1 year, where the research warrants. When necessary, legislative authority should be provided for this purpose. Agencies should also be encouraged to establish reserves or otherwise to plan renewal of contracts or grants in advance, so that renewals of longer term undertakings can be announced to institutions at least 1 year before expiration.

3) Federal agencies should consider other alternatives before establishing within universities large-scale applied and development projects (particularly those concerned with development and testing), except in such specialized fields as engineering, agriculture, and medicine, where applied research is frequently related to educational objectives. Alternatives include Federal laboratories, industrial or other private laboratories, and research centers organizationally separated from the institution proper.

Funds to cover almost two-thirds of all expenditures for research and development activities at colleges and universities come at present from the Federal Government. These Federal funds approximate a half-billion dollars, most of which sum supports research in applied fields, and come largely from defense and defense-oriented agencies.

4) No Federal agency should agree to reimburse institutions for salaries of faculty members engaged in Government-sponsored research at a rate in excess of the university rate; provided, however, that this should not apply to those faculty members granted leaves of absence to serve at research centers.

5) Government-sponsored classified research on college campuses should be reduced to a minimum consistent with national security.

6) Federal agencies should have legal authority to give the institutions title to research equipment procured by them through grant or contract funds unless a clear and definite need exists for Government control or use of the equipment. The time and expense involved in keeping records of research equipment may sometimes exceed the original value of the equipment. Much time and labor are frequently spent at the termination of research contracts in the formal and often fruitless circulation throughout the Government of long lists of highly specialized equipment which, in many cases, it would be unduly costly to relocate.

Copies of *Government–University Relationships in Federally Sponsored Scientific Research and Development* may be purchased from the Superintendent of Documents, Government Printing Office, Washington 25, D.C., for 40 cents.

Sarton Memorial Foundation

Henry Guerlac of Cornell University, president of the History of Science Society, has announced the organization of the George Sarton Memorial Foundation, Inc., a nonprofit corporation whose purpose is to promote the efforts of the late Dr. Sarton in the history and philosophy of science. The initial object of the foundation is to aid in maintaining the publication of *Isis*, the international journal for the history of science founded by Sarton in 1913, and to provide lectureships and fellowships to advance the study of the history of science.

The president of the Sarton Foundation is AAAS board member Chauncey D. Leake of Ohio State University; May Sarton, authoress and daughter of Dr. Sarton, is vice president. Morton Pepper of New York is secretary and William D. Stahlman of Massachusetts Institute of Technology is treasurer. The incorporators were C. Doris Hellman, Carl B. Boyer, William H. Stahl, Brooke Hindle, and I. E. Drabkin.

Members of the board of directors of the foundation include Elmer Belt, Marshall Clagett, Bernard Cohen, Bern Dibner, Stillman Drake, Louis Dublin, Frederick Kilgour, Giorgio de Santillana, Dorothy Stimson, Lynn White, Jr., and L. Pearce Williams.

Grants, Fellowships, and Awards

Scientific Reporting. The 1958 Waverly Gold Medal essay competition has been announced by *Research*, a monthly publication of Butterworth Scientific Publications, London. The Waverly Medal and £100 will be awarded for the best essay of about 3000 words based on some recent scientific research or new development (whether the author's work or not), giving some indication of the scientific background, the experimental results, and potential application in industry. The essay should be written in such a form that it is clearly intelligible to a scientist engaged in another field or a director of an industrial firm. The essays will be judged for technical content by specialists in the field, and for clarity of presentation and style.

A second prize of £50 will be awarded, and an additional prize, also of £50, will be given for the best entry from a competitor under 30 years of age. The competition is only open to persons at present engaged in scientific work. Entries should be posted to reach The Editor, *Research*, 4/5 Bell Yard, London W.C.2, on or before 31 July 1958.

SEATO research fellowships. Ten to 15 fellowships will be awarded for 1958–59 to nationals of SEATO member states under the program initiated last year by the Southeast Asia Treaty Organization. The program's objective is to sponsor research into the area's social, economic, political, cultural, scientific, and educational problems. Grants provide a $400 monthly allowance and air transportation. Candidates must have high academic and professional qualifications. United States citizens should apply no later than 1 Aug. 1958 to the Committee on International Exchange of Persons, Conference Board of Associated Research Councils, 2101 Constitution Ave., NW, Washington, D.C.

Tropical Medicine. Louisiana State University has received a grant from the National Institute of Allergy and Infectious Diseases to continue the program of fellowships in parasitology and tropical medicine that has been conducted for the past 3 years under a grant from the China Medical Board of New York. The new program will begin 1 Sept. 1958 and will be extended to include teachers and graduate students from nonmedical as well as medical institutions.

The fellowships will be of two types.

The first type will consist of 8 weeks in Central America, devoted to observation of diseases and health programs in several countries, in cooperation with hospitals, medical schools, and national health agencies. Opportunity will also be provided to collect teaching specimens. The second type of fellowship will consist of 6 to 12 months devoted to practical experience and research at some institution in the tropics devoted to medical or parasitological research. This type of fellowship will not be limited to the American tropics.

It is contemplated that the 8-week fellowships will be awarded in four groups each year—namely, January–February, April–May, July–August, and October–November. Each group will be limited to five fellows. The longer fellowships will be intended primarily for teachers on sabbatical leave but can include graduate students working for a doctorate.

Applications for the period October–November 1958 must be received by 31 July. For the later periods applications must be received as follows: for January–February period, by 30 September; for April–May period, by 31 December; for July–August period, by 31 March.

Applications for the 6-month and 1-year fellowships must be received at least 3 months before the desired start of the fellowship. For further information, write to Dr. William W. Frye, Dean, School of Medicine, Louisiana State University, New Orleans 12, La.

Scientists in the News

EDWARD TELLER of the University of California Radiation Laboratory at Berkeley received the Albert Einstein Medal and Award of the Lewis and Rosa Strauss Memorial Fund on 5 May at a luncheon at the headquarters of the U.S. Atomic Energy Commission. As chairman of the fund, AEC Chairman Lewis L. Strauss made the presentation. The award is given for outstanding contributions to human knowledge in the natural sciences. Heretofore, it has been made at 3-year intervals and has carried with it a cash prize of $15,000. The trustees of the fund recently decided to make the award annually and to divide the prize accordingly.

MILTON J. E. SENN, director of the Child Study Center at Yale University and chairman of the department of pediatrics in the School of Medicine, will go to the U.S.S.R. this month to study child care there. In return, a Russian physician will visit Yale late this year. Senn, Sterling professor of pediatrics and psychiatry, will travel alone as a guest of the Russian Ministry of Health.

HENRY A. MOE, secretary-general of the John Simon Guggenheim Memorial Foundation, has received the Public Welfare Medal of the National Academy of Sciences for "eminence in the application of science to the public welfare." The medal was presented at a dinner during the recent 95th annual meeting of the academy in Washington. Moe has directed the distribution of fellowships by the Guggenheim Foundation since its inception on 1 April 1925.

JOHN R. RAGAZZINI, chairman of the electrical engineering department at Columbia University's School of Engineering, has been appointed dean of the College of Engineering at New York University, effective 1 July. He replaces acting dean NORMAN N. BARISH, who has held the position since last fall, when Thorndike Saville retired. The dean-elect is a specialist in electronic computers, control systems, and related devices.

ELMER V. McCOLLUM, professor emeritus of biochemistry at Johns Hopkins University, received one of two $2500 Centenary Awards at a dinner following the Symposium on the Nutritional Ages of Man that took place under the sponsorship of the Borden Company Foundation at the Waldorf–Astoria Hotel in New York on 12 April.

BERNARD B. BRODIE, chief of the Laboratory of Chemical Pharmacology of the National Heart Institute, was awarded the Distinguished Service Award of the Department of Health Education and Welfare by secretary Marion B. Folsóm in ceremonies held on 18 April. Brodie was cited for his pioneering work in developing chemical pharmacology, which has led to greater knowledge of drug action. Brodie was also cited for his development of a number of therapeutic agents now in wide use, and particularly for his development of a significant biochemical theory on the control mechanism of the autonomic nervous system. This has contributed to understanding of how the tranquilizing drugs affect the body.

WILLIAM MALAMUD, professor and chairman of the department of psychiatry at Boston University School of Medicine and chief of psychiatry at the Massachusetts Memorial Hospital in Boston, is the new president-elect of the American Psychiatric Association. FRANCIS J. GERTY, professor and chairman of the department of psychiatry at the University of Illinois College of Medicine, Chicago, is the new president, succeeding HARRY C. SOLOMON, superintendent of the Massachusetts Mental Health Center in Boston.

H. M. BRIGGS, dean and director of the College of Agriculture of the University of Wyoming, Laramie, has been named president of South Dakota State College, Brookings. He succeeds the late John D. Headley, who was killed in a hunting accident last November.

KARL M. HERSTEIN, president of Herstein Laboratories, Inc., of New York, is to receive the 1958 Honor Scroll of the New York Chapter of the American Institute of Chemists. The award will be made at the annual dinner meeting on 9 June at Mitzi's Jager House, 1253 Lexington Ave., New York. Herstein is being honored for his long record of devoted service to the institute, to the American Chemical Society, and to the welfare of chemists in the United States.

JOHN E. WILLARD, professor of chemistry at the University of Wisconsin, has been named dean of the university's graduate school. He succeeds CONRAD A. ELVEHJEM, who will assume the presidency of the university on 1 July.

JOHANNES T. THIJSSE, professor of theoretical and experimental hydraulics at the Technical University of Delft, Delft, Netherlands, director of the Hydraulic Laboratory in Delft, and consultant to the Netherlands Government in all major water problems, has received the William Bowie Medal of the American Geophysical Union. Presentation was made on 6 May during the Union's 39th annual meeting, which was held at the National Academy of Sciences in Washington. Thijsse delivered an address entitled "In the Borderland between Geophysics and Engineering."

Six outstanding teachers of undergraduate chemistry have been named to receive awards of $1000 each under the Manufacturing Chemists' Association's 1958 College Chemistry Teacher Award Program: PAUL W. BOUTWELL, Beloit College, Beloit, Wis.; ELIZABETH DYER, University of Delaware, Newark, Del.; CARL W. HOLL, Manchester College, North Manchester, Ind.; SHERWIN MAESER, Utah State University, Logan; JESSE L. RIEBSOMER, University of New Mexico, Albuquerque; and ARTHUR E. WOOD, Mississippi College, Clinton.

The awards, first made in 1957, are presented to teachers adjudged to be ". . . personally responsible over a period of years for inspiring and holding the interest of students in the field of chemistry." Each award includes a medal and a citation. Presentation will be made on 12 June during the 86th annual meeting of the association at White Sulphur Springs, W.Va.

HAROLD [illegible] MANDEL, associate professor of pharmacology at George Washington University School of Medicine, Washington, D.C., has received the 12th annual Abel Award of the American Society for Pharmacology and Experimental Therapeutics. The award was presented at the annual banquet of the society, held on 16 April in Philadelphia in conjunction with the annual meeting of the Federation of American Societies for Experimental Biology. The $1000 award is supported by the Eli Lilly and Company, Indianapolis. Mandel was honored for his fundamental work in the field of drug metabolism and mechanism of drug action. His investigations have been concerned particularly with the metabolism of salicylates and related compounds, and with the mechanism of action of carcinostatic and other metabolites that involve specific biochemical pathways concerned in nucleic acid metabolism.

RENE J. DUBOS, pathologist with the Rockefeller Institute for Medical Research, has received the University of Chicago's 1958 Howard Taylor Ricketts Prize. The award, which consists of a bronze medal, $200, and travel expenses, was presented on 12 May at a ceremony in Chicago. Dubos, whose main field of investigation is bacteriology, is known for his development of a quick method for growing tubercle bacillus cultures, a technique useful in the accurate diagnosis of tuberculosis.

An annual lectureship to perpetuate the name of GEORGE KAMPERMAN has been established by the department of obstetrics and gynecology of Wayne State University College of Medicine. Kamperman, who has practiced obstetrics and gynecology in Detroit for 46 years, retired recently. The first George Kamperman lecture was delivered on 6 May by CURTIS J. LUND, chairman of the department of obstetrics and gynecology, University of Rochester School of Medicine.

WILDER G. PENFIELD, founder and director of the Montreal Neurological Institute at McGill University, Montreal, will receive an honorary Sc.D. degree from the University of Wisconsin in June.

HUGH H. HUSSEY, director of the department of medicine at the Georgetown University School of Medicine, has been appointed dean of the school, effective 1 July. He succeeds FRANCIS M. FORSTER, professor of neurology, who is resigning the post to devote all his time to his specialty. Forster will remain at Georgetown as director of the department of neurology.

Among the five alumni of the University of Kansas who are to receive the citation for distinguished service to mankind given by the university and its alumni association are: HENRY K. BEECHER, anesthesiologist and professor at Harvard University; BURTON McCOLLUM, petroleum geophysicist of Houston, Tex.; and D. RUTH THOMPSON, chemistry teacher at Sterling College who has been professor and head of the department for 38 years. The citations will be conferred during commencement exercises on 2 June.

BEN MOREELL, chairman of the board of Jones & Laughlin Steel Corporation, has received the Washington Award of the Western Society of Engineers for "distinguished service as a skilled engineer, outstanding naval officer, industrialist, and Hoover Commission associate." The Washington Award is the highest engineering award given in the United States. The winner is selected by a commission representing the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Institute of Mining, Metallurgical and Petroleum Engineers, the American Society of Mechanical Engineers, and the Western Society of Engineers.

Scientific visitors to North America from the United Kingdom include the following.

MARY F. LYON and H. J. EVANS of the Medical Research Council's Radiobiological Research Unit at the Atomic Energy Research Establishment, Harwell, will attend the 10th International Congress of Genetics at McGill University, Montreal, 10–27 August, and will also take part in the Radiation Biology Congress at Burlington, Vt.

D. RICHTER, director of the Medical Research Council's Neuropsychiatric Research Unit, Whitechurch Hospital, Cardiff, Wales, is visiting professor in the Menninger School of Psychiatry, University of Kansas. He will visit Boston, Washington, New York, and possibly Philadelphia before he leaves about 23 June.

G. B. B. M. SUTHERLAND, director of the National Physical Laboratory, Teddington, will be in the United States from 17 July until 5 August to attend a conference on biophysics in Boulder, Colo., organized by the U.S. Public Health Service.

DONALD M. PILLSBURY, professor and chairman of the University of Pennsylvania School of Medicine's department of dermatology, has been named president of the 12th International Congress of Dermatology, to be held in Washington, D.C., in 1962.

W. MAYER-GROSS, senior fellow in the department of experimental psychiatry, Birmingham University Medical School, England, delivered the annual Adolf Meyer Research Lecture on 14 May during the 1958 meeting of the American Psychiatric Association, which took place in San Francisco. He discussed "Model Psychoses: Their History, Relevancy and Limitations." Mayer-Gross' lecture was the second in a 5-year program sponsored by Warner-Chilcott Laboratories, the ethical drug division of the Warner–Lambert Pharmaceutical Company, Morris Plains, N.J., in cooperation with the American Psychiatric Association.

Recent Deaths

JOHN J. CHAPMAN, Baltimore, Md.; 45; since 1950 director of the Dielectrics Laboratory of the Johns Hopkins University Institute for Cooperative Research; known for his research on high voltage-high frequency limits of plastic insulation; 27 Apr.

EARL W. FLOSDORF, Doylestown, Pa.; 54; chemist-inventor; had taught at Princeton University and the University of Pennsylvania; invented a method for the freeze-drying of human blood for plasma; 29 Apr.

W. B. HART, Philadelphia, Pa.; retired superintendent of services of the Atlantic Refining Company and since 1948 a trustee of the Academy of Natural Sciences of Philadelphia; 23 Apr.

BENJAMIN F. HUBERT, Atlanta, Ga.; 73; former president of Georgia State College for Negroes; served on the National Advisory Committee on Illiteracy in 1929; 29 Apr.

ARMIN K. LOBECK, Englewood, N.J.; 71; professor emeritus of geology at Columbia University.

HENRY W. NISSEN, Orange Park, Fla.; 57; director of the Yerkes Laboratory; professor of psychology at Emory University, Atlanta; associate professor at Yale University from 1933 to 1957; author of many papers on psychology and related subjects; 28 Apr.

CHARLES F. STODDARD, New York, N.Y.; 81; inventor of the Ampico Player piano and automatic cooking devices; 29 Apr.

ALFRED WEBER, Heidelberg, Germany; 89; sociologist; emeritus professor at the University of Heidelberg, former director of the university's Institute of Sociology and Political Science; professor at the German University of Prague from 1904 to 1907; author of *Farewell to European History*; 2 May.

SUMNER B. WRIGHT, Orange, N.J.; 60; electrical engineer for Bell Telephone Laboratories; held more than 40 patents on electronic devices; 29 Apr.

Book Reviews

The Planet Earth. D. R. Bates, Ed. Pergamon, London, 1957. v+312 pp. Illus. 35s. (Published in U.S. as *The Earth and Its Atmosphere.* Basic Books, New York, 1958. 324 pp. Illus. $6.)

This is a stimulating, even exciting book, summarizing recent additions to the rapidly growing body of knowledge about the physics of our planet. It is addressed to the scientifically well-informed general reader, and to specialists in other branches of science who wish to be brought up to date on progress in geophysics. Its audience should be similar to that reached by *Scientific American,* although some parts require slightly greater scientific sophistication.

One purpose of the book is to describe for a wide public the multifarious scientific activities of the current International Geophysical Year. Most of the chapters mention measurements to be made during this period, and some consist chiefly of outlines of Geophysical Year projects. In the introductory chapter, S. Chapman gives an excellent summary of what geophysicists hope to accomplish during the Year.

Each chapter covers a single branch of geophysics, and each is written by a recognized authority. G. P. Kuiper writes on the origin and ultimate fate of the earth, K. E. Bullen on the deep interior, G. E. Vestine on the geomagnetic field, E. T. Eady on the circulation of the atmosphere, J. A. Ratliffe on the ionosphere—to mention only a few of the 17 chapters. The majority of the authors are British.

The editor has succeeded admirably in keeping the general tone and scientific level consistent from one article to the next, in avoiding duplication, and in providing cross references between articles. Inevitably, some of the chapters are more successful than others. I was particularly impressed with the clarity of the chapters on the oceans, on atmospheric circulation, on the ionosphere, and on meteors. The authors of these chapters have a knack for presenting their subjects as living fields of science, for bringing the reader into the heart of current controversies, and for showing what new developments in research are likely to prove fruitful. Some of the chapters, particularly those on geologic subjects, are marred by a tendency merely to recite conclusions dogmatically without specifying where the conclusions come from or how firmly they are based. One can sympathize with the writers' desire to crowd as much as possible into a limited space, but a nonspecialist would get a truer concept of science from a less detailed treatment and a more careful separation of fact from theory.

The illustrations are few but effective. A bibliography of both technical and popular articles provides the reader with ample suggestions for further exploration into recent work on any of the 17 topics discussed.

KONRAD B. KRAUSKOPF
School of Mineral Sciences,
Stanford University

Economic Analysis and Policy in Underdeveloped Countries. P. T. Bauer. Duke University Commonwealth-Studies Center. Duke University Press, Durham, N.C.; Cambridge University Press, London, 1957. xiii + 145 pp. $3.

This book contains three lectures given at the Duke University Commonwealth-Studies Center by the author, who is Smuts Reader in Commonwealth Studies at Cambridge University. The chapters discuss the scope, method, and potentialities of the science of economics in the study of underdeveloped countries and the impact upon that discipline of the increased interest in such areas; some of the characteristics of underdeveloped economies; and certain issues of economic-development policy. The major interest is in theoretical aspects of the problems. Illustrations are drawn for the most part from Asia and Africa.

The terseness and simplicity of the language used tends to hide the profundity as well as the originality of the thoughts presented. The author stresses the necessity of giving greater attention to methodology in social science generally. While indicating that there are certain processes which are universally similar, he points out that there are certain differences (particularly in the institutional aspects) between areas, which must be carefully studied. In underdeveloped countries, for example, there are likely to be particularly severe limitations on the amount of statistical evidence available, and this makes direct observation more important. Moreover, political considerations are likely to influence not only the findings but also the selection of problems.

It is pointed out that the problems relating to rapid and uneven growth are quite different from those of stagnation and that, for various reasons, such as an unsympathetic attitude toward agriculture and an inclination to confine attention to easily measurable economic categories, there has been neglect, in contemporary literature, of the establishment, extension, and improvement of agricultural properties as a form of capital formation. There has been a similar neglect with respect to traders' inventories.

The important contribution of migrants to economic development in emerging economies is discussed at some length in the second chapter, but it is not indicated how what has been termed "international demonstration effect" or "increase in the desire for higher consumption" stimulates internal as well as international population movement and thereby further removes some of the major obstacles to change.

A case is made for cheap labor as an asset of underdeveloped countries, but in opposing the establishment of minimum wages and maximum hours, Bauer does not make it clear that it is real costs which must be considered, or wages in relation to productivity, as well as the promotion of local or individual well-being as a possible stimulus to greater effort.

It is pointed out that development, as such, is not necessarily of benefit to all people or to all segments of a society and that costs which may not be evenly distributed are always involved. As Bauer can testify, so-called humanitarians are frequently extremely insensitive to the results of their proposals and conduct.

In discussion of the merits and disadvantages of an emphasis on cash crops in promoting development, no mention is made of benefit distribution, which, while to some extent an independent problem, is nevertheless frequently if not always related to development processes.

The importance of governmental intervention in development is admitted, but great caution is advised in the adoption of both restrictive and promotional measures.

ROBERT CUBA JONES
Mexico City, Mexico

The Development of Titrimetric Analysis till 1806. E. Rancke Madsen. Gads, Copenhagen, Denmark, 1958. 239 pp. Illus.

The cover of this paper-bound, well-printed book attracts by the reproductions of old figures showing tubes and pipettes used in the early days of titrimetry. A look at the title may induce the question, Why till 1806? The full answer is given on page 195. In that year appeared Descroizille's article "Notices sur les alkalis du commerce," which is "a milestone in the development of titrimetry." "It is the first step towards assembling in one unity—titrimetric analysis—a number of different analytical methods which in their origin do not seem to have anything in common." It was to be followed by H. Schwarz, *Ueber die Massanalysen.* . . . (Braunschweig, 1850), the full title of which is listed in reference No. 287 (the last of the references bears the number 337).

Having thus started at the end of the book, we might go back to the beginning, of the book and of titrimetry, to Robert Boyle's "Experimental history of colors" (1663) and the use of lignum nephriticum extracts—the first known example of fluorescence—as indicators for acids and alkalies. It took about one hundred years before indication by color change was applied in titrimetry, although several descriptions of analysis by titration appeared in the meantime. Francis Home used the cessation of effervescence or the clearing of solutions from precipitates as indications, in 1756. In 1767, William Lewis relied on "the purplish blue paper used for wrapping sugar in" to show free acid or alkali at the end point of his titrations.

Methods for determining the alkaline strength of plant ashes, the concentration of vinegar, and the hardness of water; for following the purification of saltpeter from calcium and chlorides; and for measuring the then relatively new mineral acids of commerce were the practical aims of titrations by Wenzel, Bergman, Morveau, and almost all the great chemists of the 18th century. Indicators were extracted from flower petals, and since these are not available in winter, James Watt proposed red cabbage leaves as a source (1784). When Berthollet's chlorine bleach came into use, "strength" measurements were needed, and the redoximetric methods used for chlorine were adapted to the determination of dyestuffs. The assembly of pipettes and graduated glasses developed by Descroizille received the name *"le berthollet"* from him. Such methods became more frequently used, and the degree of purity was called "titre" by Macquer in 1778.

E. Rancke Madsen, professor at the Technical University of Denmark, reports about his very thorough study clearly and systematically. He gives extensive quotations, in the original language when this was English, French, or German and in translations from the Swedish. Particularly valuable features are his account of the experimental tests he carried out in accordance with the old descriptions and his interpretation of them in our scientific language. Together with his general discussion of quantitative analysis, these experimental data enhance the interest in the historical foundations of our methods. The book thus may become a valuable tool in the teaching of analytical chemistry—and, incidentally, in the teaching of French and German to chemists, through the meaningful and elegant examples provided in the many quotations.

EDUARD FARBER

Washington, D.C.

The Story of Life. H. E. L. Mellersh. Putnam's, New York, American ed. 1, 1958. 263 pp. Illus. $3.95.

A scientist reviewing this book by a layman for laymen is stricken with ambivalence. He wants to praise and to promote it, but he cannot honestly do so without such qualification as may seem to be a condemnation. Here is a story that everyone should know: the evolutionary history of living things. It is set forth interestingly and clearly, although the style is somewhat uneven. The aim is certainly worthy: to instruct those willing to learn about evolution, to convince the dubious, and to reconcile the pious. And yet on most pages there is at least one statement that is not just right, not quite factually correct, not entirely representative of current scientific thought, not wholly free of unwarranted implications.

The author claims as an advantage that his language is "by no means always . . . strictly scientific." That does not explain or excuse innumerable sentences that are not true in detail and that could be made true with no loss of simplicity. "The ridge of plates along the back of the stegosaurus . . . may have served as protection against tyrannosaurus"—but *Stegosaurus* and *Tyrannosaurus* were not contemporary, by millions of years. "Hesperornis, a diving bird essentially similar to the modern bird in wings and tail"—but *Hesperornis* had no wings. "The insects we can dismiss summarily: they do not learn"—but they do learn. Those are average, not the most egregious, examples of a multitude of misstatements.

More subtle and at least as frequent are phrases suggesting failure to grasp the essence of pertinent scientific methods and viewpoints; for example, "The species of Primate," where the Order Primates is meant; "Scientists are singularly free and easy with the Greek and Latin tongues and singularly unforthcoming in explanation of exactly what they mean when they use them . . . [A fossil animal] was christened *Proconsul* and the scientists have rather surprisingly accepted the title"; "The social insects . . . [obey] the law that Christians are expected to follow, of walking contented in that way of life into which it has pleased God to call them. . . . They do what they are created to do." Equally frequent are examples of the pathetic fallacy and of anthropomorphism, for which, indeed, there is occasionally an apology, but not often enough.

The crucial chapters on explanations of evolution divide these into "the orthodox" (Darwinism and so-called neo-Darwinism)and "the unorthodox" (neo-Lamarckism and vitalism, which are wrongly considered synonymous). That may be fair enough in itself, but it is not fair to the reader, while pretending a judicious neutrality, to imply strongly that "the unorthodox answers" are more likely to be true, and to bolster this by giving a highly inadequate and partly inaccurate summary of "the orthodox answers."

Might the anxious reviewer resolve his ambivalence by saying that the book is good over-all but not in detail? But perhaps that is too much like the curate's egg, which, after all, was bad only in detail.

G. G. SIMPSON

American Museum of Natural History

Methods in Enzymology. vol. IV. Sidney P. Colowick and Nathan O. Kaplan, Eds. Academic Press, New York, 1957. xii + 979 pp. Illus. $24.

This book is the last of a series which attempts to provide a compendium of methods for the enzymologist. The earlier volumes, which by now are standard equipment in most biochemistry laboratories, covered the preparation and assay of enzymes and substrates. Volume IV is entitled *Special Techniques for the Enzymologist.*

This volume contains three main sections: "Techniques for Characterization of Proteins," "Techniques for Metabolic Studies," and "Techniques for Isotope Studies." As with the earlier volumes, the main sections consist of a number of individual articles written by recognized authorities. There is a total of 35 such papers, and the list of authors includes many of the outstanding workers in the

respective fields. For example, A. Tiselius writes on "Electrophoresis," F. H. C. Crick on "X-ray diffraction of protein crystals," F. S. Sjöstrand on "Electron microscopy of cellular constituents," K. Bloch on "Synthesis and degradation of labeled steroids," and A. A. Benson and M. Calvin on "Intermediates of photosynthesis."

Presumably due to limitations of space, a number of articles in this volume contain a review of general principles plus references to appropriate sources for detailed laboratory directions. On the other hand, when detailed directions for a method are given, as in the earlier volumes, only one of a number of commonly used techniques is usually covered. An example of this is the section on "Determination of amino acid sequence in proteins." R. R. Porter contributes a comprehensive manual on the use of fluorodinitrobenzene for this purpose. The pipsyl method is also described, but the Edman and hydrazinolysis methods are omitted.

The over-all quality of the book is very good. The review articles have sufficient detail to make them useful to the average biochemist who is not actually working in the field. Among the more detailed articles, the following should be particularly useful: "Techniques for assay of respiratory enzymes," by B. Chance, which covers mainly the sensitive spectrophotometric methods; "Micromethods for the assay of enzymes," by O. H. Lowry; and the section on "Synthesis and degradation of isotopically labeled compounds," which contains directions for making more than 150 preparations of interest to biochemists. The editors plan a supplementary volume to remedy deficiencies and revise outdated procedures.

RICHARD S. SCHWEET
City of Hope Medical Center,
Duarte, California

Biochemical Cytology. Jean Brachet. Academic Press, New York, 1957. xi + 516 pp. Illus. $8.80.

This book is the outcome of a series of lectures given by the author at the Indian Cancer Research Centre in Bombay in 1956, as well as lectures to his own students at the University of Brussels. It is intended for rather advanced students and investigators who have much background knowledge of biology and chemistry, including descriptive cytology, biochemistry, embryology, and genetics. The book is written in a very direct and clear style. This is particularly impressive inasmuch as English is not Brachet's native language. For help in this and other aspects of the work he acknowledges the assistance of A. R. Gopal Ayengar, H. Peters, W. A. Jensen, R. Logan, and P. Couillard.

The field that one may designate as biochemical cytology has been developing rapidly and extensively in recent years. An up-to-date text in this important area of biology is, therefore, most welcome and useful to all students and investigators whose interests impinge thereon. Brachet has succeeded admirably in including the most current research in this field. In fact the references listed are largely to publications appearing within the last three or four years. This work also has the merit of having been written by one who has long been active in research in this field and who has made some of the most important contributions to it. The opinions and estimates that he gives of the significance of the work of others are thus largely based on firsthand experience with the materials and techniques.

Brachet does not present a definition of "biochemical cytology," but in a sense the contents of the book serve to indicate what he considers mainly to comprise the domain of this field. Some idea of the scope of the work may be obtained from the chapter titles, which are as follows: "The recent history of biochemical cytology"; "Brief survey of the techniques"; "The cytoplasm of the resting cell"; "The nucleus of the resting cell"; "Mitosis"; "Nucleic acids in heredity and protein synthesis"; "Nucleocytoplasmic interactions in unicellular organisms"; "The nucleus and cytoplasm in embryonic differentiation"; and "Remarks on cancer cells." There is a final short chapter, called "Final remarks," in which the difficulties in defining "life" are discussed in relation to cell fragments and cell constituents.

Throughout the text Brachet has paid particular attention to the nucleic acids. Such attention is certainly merited in view of the great advances that have been made concerning the role of these substances in heredity and protein synthesis and in view of the considerable research activity in this field. These substances provide, to a large extent, a central and integrating theme for the extensive biochemical and modern morphological studies that are reviewed. One might think of a number of topics that are not discussed, or that receive scant attention in the text, and that could be considered a part of this field. For example, current research on collagen and on myofibrillae provides excellent and interesting material for discussion of correlations between biochemistry and structure. Another topic of great current interest is that of the abnormal hemoglobins, which would seem as appropriate for discussion under biochemical cytology as under biochemical genetics. However, one certainly cannot hope to find included in a text of reasonable size, written by one author, all th[is] might be considered a part of a [fie]ld that encompasses as much of biology [as] biochemical cytology does. The author has done an excellent job of bringing [to]gether, in a well-coordinated and integrated form, most of the research that is of special current interest in the new cytology.

ALBERT TY[SON]
Division of Biology,
California Institute of Technology

Doctor and Patient in Soviet Russia. Mark G. Field. Harvard University Press, Cambridge, 1957. xviii + 26[1] pp. $5.

Reviewing a book on medicine in the Soviet Union is beset with dangers common to all studies of the Soviet system. "failure explicitly to condemn is viewed by some as tantamount to approval, and failure explicitly to praise is taken by others as the equivalent of criticism."

This is a serious study by a serious student of Soviet matters. The author is not a physician and stays close to the sociological study of the doctor and the patient and their interrelationship within the Soviet system. He does not undertake to deal with the technical aspects of the practice of medicine, or with such related topics as postgraduate training and medical research. One could wish that the book had been based on more extended personal observation than that provided by a month's tour in the Soviet Union and that interviews with refugees did not represent so important a proportion of the total information, upon which some deductions are, inevitably, framed. These shortcomings are recognized clearly by the author and should be remembered as clearly by the reader.

For me, the most penetrating insight into the role of the physician in the Soviet Union was derived from a sentence on page 26: "his living condition, his satisfaction and dissatisfaction, the importance given the kind of services he dispenses, and even the sex composition of the profession resemble to a striking degree those of the elementary and secondary school teacher in the United States."

The book deserves careful reading by physicians and, for that matter, by patients, including those of professional calling. An exposition of this kind should yield a greater understanding of Soviet medicine and its relation to the Soviet system as a whole, and perhaps even some useful reflections about American medicine and its role in our social structure.

MICHAEL B. SHIMK[IN]
National Cancer Institute,
National Institutes of Health

Reports

Production of Anaphylaxis in the White Mouse with Soluble Antigen-Antibody Complexes

Definitive information on anaphylaxis is still lacking with respect to the tissue sites at which the causative antigen and antibody interact and the mechanism by which antigen-antibody interaction leads to shock.

Germuth and McKinnon (*1*) have recently made the important observation that soluble complexes of antigen and precipitating antibody produce immediate anaphylactic shock in the guinea pig. This anaphylactigenic action of soluble antigen-antibody complexes is compatible with the earlier observation that anaphylaxis can be produced with "univalent" antibody which forms only soluble complexes with antigen (*2*, p. 97). The findings of Burdon (*3*) that severe passive anaphylaxis in mice could only be produced by intravenous challenge with antigen when antibody was still abundant in the blood or by the intravenous injection of "suitably proportioned" antigen-antibody mixtures may have depended on the anaphylactigenic action of soluble antigen-antibody complexes. Since the use of soluble antigen-antibody complexes presents a new approach for investigating the mechanism of anaphylaxis, it appeared desirable to study the action of these complexes in the mouse, in which the course of anaphylaxis differs from that observed in the guinea pig (*4*).

The mice used were of mixed sexes of the white Swiss strain. They were from 6 to 9 weeks old and ranged from 22 to 27 g in weight. The antigen employed was crystalline bovine serum albumin (BSA) dissolved in physiological saline (*5*). The heat-inactivated rabbit antiserum that was used contained 2.32 mg of antibody N per milliliter (*6*). It was produced by the method of Freund (*7*) from heat-killed bacillus Calmette-Guérin.

The first method used to prepare soluble antigen-antibody complex was to add antiserum to excess antigen. The quantity of antigen used was eight times the amount determined to be present in a precipitate formed in the zone of equivalence. The antigen-antibody mixtures were incubated at 37°C for 20 minutes and cleared by centrifugation. The second method of preparing soluble antigen-antibody complex was that of using excess antigen to dissolve a precipitate obtained in the zone of equivalence. The precipitate was washed four times in physiological saline at 4°C, and a concentrated solution of antigen was added, containing a total amount of antigen equal to ten times that present in the precipitate. This mixture was agitated and incubated for 40 minutes at 45°C and centrifuged to remove the small amount of undissolved precipitate. All preparations were injected into the tail veins of mice in a volume of 0.4 ml. In the first experiment, a dose of soluble complex prepared by the first method and containing 0.6 mg of antibody N, produced anaphylactic death in 15 of 16 mice. A dose of soluble complex prepared from a precipitate by the second method and containing 0.48 mg of antibody N produced anaphylactic death in 10 of 16 mice. Control preparations were: BSA in normal serum, anti-BSA serum, bovine gamma globulin (*5*) in anti-BSA rabbit serum, BSA alone, and supernatant fluids from mixtures of antigen and antibody in the zone of equivalence. The number of animals in the groups given the control preparations varied from 6 to 13.

Whereas animals of both test groups reacted uniformly, with typical severe anaphylaxis (*8*) within 2 to 5 minutes and deaths occurred in from 15 to 35 minutes, the animals that received control preparations were not affected. Although the lower mortality in the mice which received the complex prepared from washed BSA–anti-BSA precipitate was presumably due to the lower dose of complex given these animals, an alternative possibility is that the antigen-antibody aggregates derived from washed precipitates were larger (*9*) and less anaphylactigenic.

In the next experiment mice were injected intraperitoneally with 0.1 ml of *Hemophilus pertussis* vaccine (*10*) (48.8×10^9/ml in 1:10,000 merthiolate) 5 days before challenge with antigen-antibody complex. Whereas the injection of a dose of soluble complex prepared by the first method and containing 0.12 mg of antibody N, caused anaphylactic death in 18 of 18 pertussis-vaccinated animals, only 5 of 18 nonvaccinated animals died. This marked increase in the susceptibility of the pertussis-vaccinated mice to shock with the complex is similar to observations which have been made in pertussis-vaccinated mice sensitized actively (*11*) and passively (*12*) and shocked with antigen in the usual manner.

Because it is unlikely that the antigen-antibody complexes used underwent significant dissociation in vivo (*1*, *13*), anaphylaxis was presumably caused by soluble antigen-antibody complexes acting either within the circulating blood or in surrounding tissues into which they may have diffused.

Since it is probable that soluble antigen-antibody complexes formed by either nonprecipitating or precipitating antibody in the region of antigen excess consist principally of aggregates of two or three molecules (*14*), the size of the aggregates may not be sufficient to prevent, or perhaps even markedly retard, their passage to extravascular sites (*15*). The observation that anaphylaxis produced with soluble antigen-antibody complexes was typical in all respects suggests that the site of antigen-antibody action and ensuing events leading to anaphylaxis are the same regardless of whether shock is induced in the usual manner by injection of antigen or by the injection of soluble preformed antigen-antibody complexes.

The results reported here do not support or refute the suggestion of Benacerraf and Kabat (*2*, p. 517) that the "time-consuming reaction" responsible for the incubation period necessary for maximum sensitization to passive anaphylaxis in the guinea pig represents the time necessary for the fixation of antibody to cells, for there is no evidence to preclude the possibility that the antigen-antibody complex itself must "fix" to cells in order to produce shock. Neither do the present results justify any change in the common opinion that the speed and severity of shock are determined by the rate at which antigen reaches "fixed antibody"; for the rate at which preformed soluble antigen-antibody complex reaches the sites where antigen-antibody injury is produced may likewise determine the speed and severity of the resulting shock. Indeed, the amount of the antigen-antibody complex at "injury

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sites" and the speed with which it accumulates at such sites, regardless of whether it forms *in situ* or arrives preformed, may be the principal determinants of shock. The concept that the primary action of the soluble antigen-antibody complex is at extravascular sites and involves complement is compatible with the proposition that anaphylaxis in the mouse results from the rapid release of shock "mediators" from tissue mast cells (*16*).

In summary, it should be emphasized that much additional evidence will be necessary to establish the site at which primary cell injury is produced by the action of antigen-antibody complexes and the ensuing events which lead to anaphylaxis.

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29 November 1957

Production of Injury to Feline Central Nervous System with Nucleic Acid Antimetabolite

Biochemical and autoradiographic investigations in this laboratory have shown that neurons and glia within the mature mammalian neuraxis actively incorporate C^{14}-labeled adenine and orotic acid into pentose nucleic acid (*1*). It appears likely that this is related to the turnover of protein which occurs in nerve cells (*1*, *2*) and glia (*1*).

In order to test this hypothesis and to investigate the function of pentose nucleic acid in the central nervous system, we have attempted to interfere with pentose nucleic acid turnover by the use of nucleic acid antimetabolites. These substances, administered orally and parenterally, have been employed extensively in animal experimentation and in the treatment of neoplasms and blood dyscrasias in man. Acute and transient disturbances such as ataxia, weakness, and convulsions have occurred when massive doses are given to animals (*3*), but no delayed and lasting neurological symptoms have been reported. It is possible that the blood-brain barrier protects the central nervous system from these antimetabolites. In the present study this obstacle was circumvented by the expedient of injecting the antimetabolites into the subarachnoid space. In the course of this investigation, a pyrimidine antimetabolite was found to produce a consistent and striking neurological syndrome in cats. This, together with preliminary neuropathological and histometabolic observations, constitutes the subject of this report.

A fluorinated pyrimidine, 5-fluoroorotic acid (*4*), was used because of the previously demonstrated incorporation of orotic acid into pentose nucleic acid in the feline neuraxis (*1*). The biological activity and tumor-inhibitory properties of this substance have been described by Heidelberger *et al.* (*5*). 5-Fluoroorotic acid or its sodium salt (20 to 30 mg/ml in water; because of its poor solubility, it is used as a supersaturated solution which is heated and cooled to body temperature at time of injection) in a single dose of 3 to 10 mg is administered by intracisternal injection to cats anesthetized with pentobarbital sodium or ether. In some animals a second injection is given about 1 week after the first, to make a total dose of 5 to 15 mg.

Following an initial symptom-free period of 5 to 10 days, the cats undergo a change in behavior. They become somewhat sluggish and inactive. Within several days an unsteadiness in walking becomes apparent. This rapidly progresses and becomes a severe ataxia involving the trunk and extremities. There is no gross paralysis, but all movements are marred by typical cerebellar oscillations. Animals walk with a lurching, reeling gait. In advanced stages of this condition they are so helpless that they are unable to eat or move about. Polypnea is frequently present, and nystagmus is occasionally seen, particularly on rapid head movement. At times, twitchings of the face and vibrissae appear which resemble the fasciculations of motor neuron disease; these are abolished by pentobarbital anesthesia. Tonic and clonic convulsive movements have been noted preterminally in several immature cats.

No attempt has been made, thus far, to nurse animals beyond the tenth day of overt illness; two animals died of this illness, probably because of respiratory

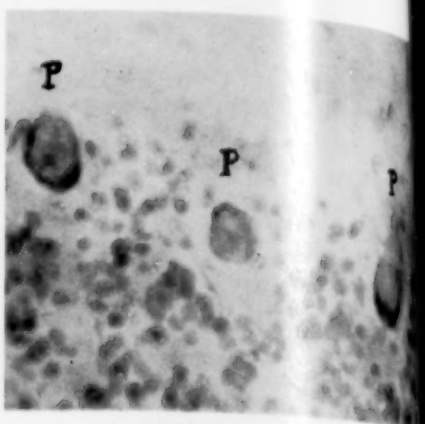

Fig. 1. Cerebellar cortex from a cat with severe cerebellar ataxia produced by the intracisternal injection of 5-fluoroorotic acid 17 days before sacrifice. Note the perinuclear depletion of basophilic substance, only a peripheral rim persisting in the cytoplasm of the Purkinje neurons (*P*). (Gallocyanin chromalum stain) (about × 360).

or bulbar involvement, but the remainder were killed. No evidence of hematologic or gastrointestinal involvement was noted. This contrasts with the reported results of oral and parenteral administration of nucleic acid antimetabolites where these systems are involved (*3*). In control studies, orotic acid had no deleterious effect when given in doses similar in amount. Neurological symptoms were not observed when the drug was given in large doses by intraperitoneal injection.

Histological examination of the brain and spinal cord of these animals has not been completed. However, a striking lesion has been found in the cerebellum in all of six brains examined to date. In routine Nissl– and hematoxylin-eosin-stained sections, most of the Purkinje neurons of the cerebellar cortex revealed advanced central chromatolysis (Fig. 1). Thus the severe cerebellar deficit exhibited by these animals can be ascribed to Purkinje cell damage. Occasional neurons of the brain stem and spinal cord showed similar though less marked alterations. This may account for the other neurological symptoms noted, such as polypnea and convulsions.

Studies have been completed on two fluoroorotic acid treated cats which were given L-methionine-S^{35} in doses of 100 μc (specific activity 10 to 14 μc/mg) 4 hours before sacrifice. Autoradiographs prepared from formalin-fixed, acid- and lipid-extracted tissue sections of brain and spinal cord (*1*) showed marked reduction in the radioactivity of neurons and glia by comparison with untreated animals. However, the intracisternal route of injection may not give quantitatively reproducible results, and only tentative conclusions can be drawn from this evidence alone. The spinal ganglion neurons in these preparations, on the other hand, exhibited a relatively nor-

degree of r[illegible]oactivity; in untreated animals under these conditions, spinal ganglion neurons give a less intense autoradiograph than nerve cells within the neuraxis (*1*). These observations provide evidence that, in cats treated with fluoroorotic acid, the ability to incorporate labeled methionine into the protein of nerve cells and glia within the neuraxis is impaired but that the ability to incorporate it into the protein of spinal ganglion neurons is not.

Several considerations make it seem likely that the effects of intracisternal injection of 5-fluoroorotic acid in cats result from an interference with pentose nucleic acid metabolism. The chromatolysis of Purkinje neurons itself represents a quantitative reduction of cytoplasmic pentose nucleic acid (*6*). The course of this syndrome—that is, the symptom-free latent period, gradual onset, and progressive worsening—resembles the toxic effect of nucleic acid antimetabolites on bone marrow, liver, intestinal mucosa, and tumors (*3*). The apparent diminution in incorporation of labeled methionine into nerve and glial cell protein furnishes further support for this hypothesis, since pentose nucleic acid plays an important role in protein synthesis (*7*). The significance of this evidence is enhanced by the finding that spinal ganglion cells show little reduction in incorporation of labeled methionine; 5-fluoroorotic acid would be expected to have much less effect on these cells because they incorporate orotic acid into pentose nucleic acid at a relatively slow rate (*1*). Possible mechanisms of action of 5-fluoroorotic acid include: (i) competitive or noncompetitive blocking of the incorporation of normal precursors into pentose nucleic acid, leading to depletion of the acid; and (ii) the incorporation of the fluorinated pyrimidine analog or its derivatives into pentose nucleic acid, rendering it metabolically ineffective or harmful. The proximity of the cerebellum to the site of injection and its active turnover of pentose nucleic acid probably account for the early and severe derangement of this portion of the neuraxis. The production of neurological deficit, neuronal lesions, and impairment of protein metabolism in nerve and glial cells by a nucleic acid antimetabolite indicates the possibility that some "degenerative" and other disease processes which occur within the central nervous system may be caused by biochemical or other disturbances in nucleic acid metabolism (*8*).

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Relation of Structure to Adsorption of Substances during Crystallization of L(−)Tyrosine

The incorporation of impurities into growing crystals has attracted considerable attention for a long time. Whereas the prevailing emphasis has been directed toward modification of crystal growth or habit, virtually nothing has been said of the relationship between chemical structure and incorporation.

With L(−)tyrosine as the parent substance, and chemically related substances as the impurities, the incorporation by the growing crystals was studied by the use of the spectrophotometric method of Goodwin and Morton (*1*). The data, illustrated in Fig. 1, demonstrate that the incorporation of the various substances used is specific. No incorporation was observed with hydrocinnamic acid (not shown) up to 0.016*M*, where solubility difficulties are encountered. In the case of L(−)alanine (not shown), a concentration of 0.047*M* was required before incorporation could be detected [0.041*M* L(−)alanine per mole of tyrosine].

The adsorption process is clearly evident in the cases of L(−)histidine, D(+)-phenylalanine, and L(−)phenylalanine. The amount of impurity incorporated is seen to be related not only to the structural similarity of the mother substance and the impurity but also to the spatial relationships of the two substances, as evidenced by the stereoisomeric specificity of the phenylalanine isomers.

For L(−)phenylalanine, the adsorption empirically resembles that of Henry's law or a simple Langmuir isotherm, which is indistinguishable from it at small adsorptions. It is possible to conceive of the growing crystal, because of its ability to present a changing surface to its surrounding medium, as obeying the Langmuir isotherm for a given surface and Henry's law for the sum total of surfaces generated, resulting in what is known as a solid solution. In this instance the heat of adsorption and the adsorption capacity of each new surface would have to remain constant. When this does not occur, deviations from linearity would be expected. This, perhaps, is part of the exacting requirements necessary for specificity of a stereoisomeric adsorption.

Additional information concerning this specificity is obtained from the examination of the molecular models of the interacting substances. These are shown in Fig. 2. Models with the same configuration are depicted as L. The stereoisomer of this configuration is arbitrarily designated D. If we assume that the complementary charged groups of the two interacting substances are active in the adsorption process, the charged amino group of one is placed in the position of closest approach to the carboxylate ion of the other, the rings of both molecules being in the same plane. In the case of L(−)tyrosine and D(+)phenylalanine, the two carboxylate ions are capable of very close approach, and hence one would anticipate an inhibitory effect from the resulting repulsion. This is actually reflected in the decreased adsorption at higher concentrations (Fig. 1). In the case of L(−)phenylalanine and L(−)tyrosine, this proximity of the carboxylate ions does not exist. In fact, it is possible that there is a hydrogen bond between the two carboxylate ions, thus enhancing the adsorption.

These experiments indicate that no one bond type is responsible for the adsorption by tyrosine. The ionic bonds, which are the most important in the crystal, as evidenced by the high melting points of dipolar ions generally, must be supplemented by other forces. With the exception of hydrocinnamic acid, all the substances studied may be looked upon as derivations of alanine. Hence, if the

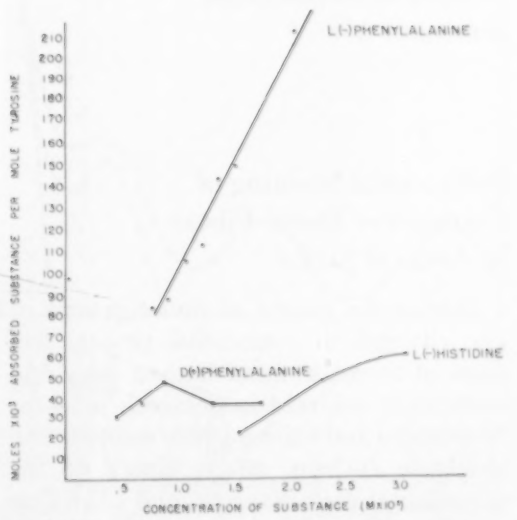

Fig. 1. Adsorption of substance by L-tyrosine during crystallization.

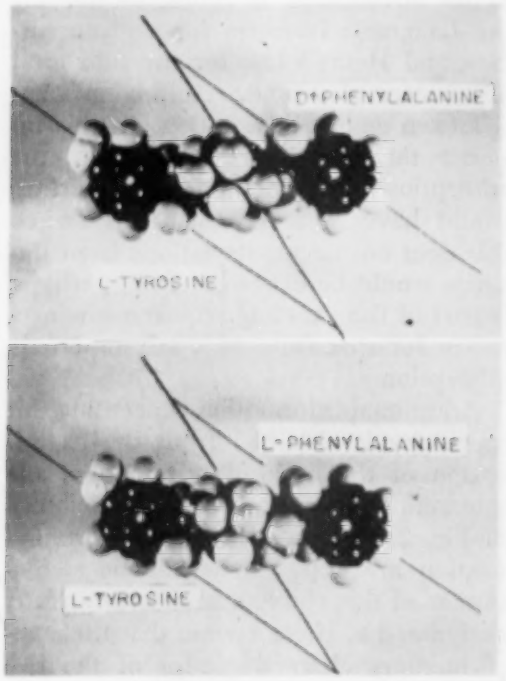

Fig. 2. (Top) Molecular models of L-tyrosine and D(+)phenylalanine with complementary charged groups in juxtaposition. Note the close approach of the two negative carboxylate oxygens (labeled O). (Bottom) Molecular models of L-tyrosine and L-phenylalanine. Note the separation of the carboxylate oxygens made possible by a hydrogen bond.

complementary charged groups alone were responsible for the adsorption, one would anticipate no differences among the reactants, or possibly even a stoichiometric relationship. The fact that this is not observed indicates that other factors, such as steric relationship and hydrogen bonding, must be present to supplement the initial binding of the charged groups (2).

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Differential Staining of Connective Tissue Fibers in Areas of Stress

During the course of investigations of age changes in connective tissues, sections of formalin-fixed human jaws and teeth were oxidized in peracetic acid for 30 minutes and subsequently stained with aldehyde fuchsin. Many fibers of the periodontal membrane stained a brilliant purple; others remained unstained (Fig. 1). The fibers that remained unstained were birefringent and therefore are believed to be collagen. The purple-stained fibers were interspersed between collagen fibers and were not birefringent. They were round, elliptical, or flattened on cross section and varied from 3 to less than 0.5 μ in diameter, the larger ones exceeding 2 mm in length.

In the mid and apical portions of the roots of teeth, these fibers were anchored either in the cementum or bone on one end, and they frequently ramified while they followed the course of the principal fibers. It was not possible to trace a single fiber that extended from the tooth to the bone. In the area of the cementoenamel junction, the fibers were anchored in the cementum and either curved upward into the gingiva, along with the collagen fibers, or joined with the transseptal group. In addition, at all levels of the periodontal and gingival tissues in mesiodistal sections, numerous fibers were seen, cut crosswise or tangentially; this indicated their many-directional course.

These fibers were also found in tendons (Fig. 2), in ligaments, in the adventitia of blood vessels, in the connective tissue sheath surrounding hair follicles, and in the epineurium and perineurium in the human being. In sections of tendons and ligaments they were found internally as well as surrounding the collagen bundles, taking the same course as the collagen fibers.

The fibers were found in the periodontal membranes of human beings, mice, rats, and guinea pigs and in the Achilles tendons or patellar ligaments, or both, of human beings, monkeys, mice, rats, guinea pig and a turkey. In the guinea pig periodontium, some of these fibers were flattened like a ribbon and were oriented in an apical-occlusal direction, as they were in the periodontal membranes of developing human teeth.

With the usual staining procedures, connective tissue fibers of periodontal membranes, tendons, and ligaments appear to be composed almost entirely of white collagen. Fine elastic fibers have been described in tendons (*1*), and a few elastic fibers are found in human periodontal membranes, associated with blood vessels and nerves and not arranged to support the teeth during mastication. The fibers described in this report do not stain with any of the elastic tissue stains and were not dissolved in formalin or alcohol-fixed sections by elastase, as elastic tissues were in comparably treated skin sections. Reticular fibers of the spleen and lymph nodes were not stained by this method, and reticulum stains did not differentiate these fibers.

Undoubtedly these fibers have been called collagen heretofore and further investigation may reveal them to be a form of collagen that develops in areas of stress. Since they were not found in skin or in granulation tissue, it is unlikely that they are a form of procollagen or aged collagen.

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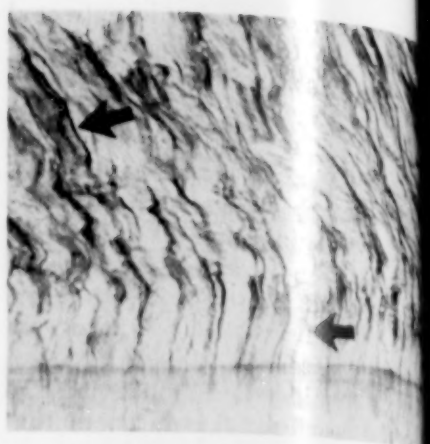

Fig. 1. Section of tooth and periodontal membrane from a white male, aged 2[illegible]. Arrows point to the special fibers reacting with aldehyde fuchsin after peracetic acid oxidation. Neighboring collagen fibers are unreactive and pick up the counterstain. Horizontal band at bottom, cementum; remaining area, periodontal membrane (about × 650)

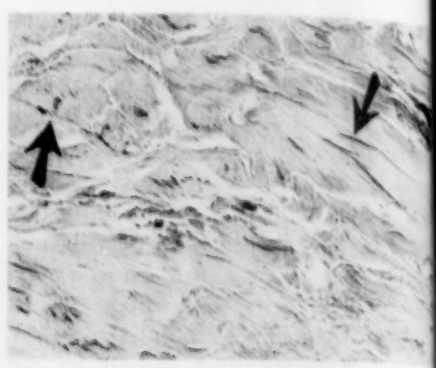

Fig. 2. Section of Achilles tendon from a white male aged 53. Arrows point to special fibers reacting with aldehyde fuchsin after peracetic acid oxidation. (about × 225)

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24 December 1957

Natural and Fission-Produced Gamma-Ray Emitting Radioactivity in Soil

The gamma-ray spectrum emitted by present-day surface soil reveals the presence of several lines which do not pertain to either the thorium or uranium series or to K^{40}. These additional gamma-ray lines come from radioactive fission products in fallout, and previous investigations at Argonne National Laboratory have shown that these gamma-ray spectra may be gotten *in situ* by placing a

...tillation detector within a few centi...ters of the surface of the ground (*1*). ...e to the large amount of scattering ...d absorption inherent in such a mas... source, little spectral detail is appar... below 0.5 Mev under the conditions ... measurement specified above. How...er, by using a finite amount of soil and ... counting under conditions of low ...kground radiation (*2*), more detailed ...ectra may be obtained, and fairly ac...rate measurements of radioactivity are ...de possible.

In Fig. 1 the gamma-ray spectrum of topsoil collected in 1950 is compared with that of topsoil collected during Oct. 1957. Both samples were taken from the Argonne site, and the amount of soil counted was 1 kg in each case. The contemporary sample was obtained from the top 1.5 cm, whereas the older sample contained approximately the top 2 in. of soil. The spectra were taken with a 3- by 4-in. NaI crystal, canned in electrolytic copper, mounted on a DuMont 6364 photomultiplier tube enclosed in stainless steel. Each soil sample was contained in a 1-lit polyethylene bottle, 1 kg of soil constituting a right circular cylinder 14 cm high and 9 cm in diameter. A Lucite holder was mounted concentrically on top of the crystal to insure that the geometrical relationships could be reproduced. One-half inch of Lucite was placed between the flat bottom of the bottle and the crystal to absorb the 0.35 Mev beta-rays from Rh^{106}. Pulse-height analysis was carried out with an Argonne type 256 channel analyzer.

Figure 1 shows clearly three lines which are present only in the recently collected top soil. The peak at approximately 0.5 Mev is actually a combination of lines from Ba^{140}-La^{140}, Nd^{147}, Ru^{103}, and Rh^{106}. The one at 0.75 Mev is from Zr^{95}-Nb^{95}, and that at 1.6 Mev is due to La^{140}. The electronic gain is not sufficient to show the region around 0.14 Mev, but here two lines exist which are due to Ce^{141} and Ce^{144} lying in close proximity.

The pulse-height spectrum of the fallout radiation, as shown in Fig. 1, is somewhat misleading as an indicator of relative radiation dose at the earth's surface, since fallout debris is confined mostly to the surface, whereas the natural activities are rather uniformly present throughout the soil.

The dose pertaining to these various radioactive materials can be calculated by first determining the concentration available and then taking into account their distribution in depth. In order to determine the activity due to each radioisotope in soil it is necessary to break the net spectrum (fission products plus natural activity) down into its individual components. The method used is illustrated in Fig. 2 for a particular soil sample. The most energetic line is that at 2.62 Mev, due to Th C″. By using a mock soil consisting of Na_3PO_4 mixed with monazite sand of known thorium content, made up to 1 kg weight and similarly placed with respect to the crystal, the thorium spectrum may be normalized at the 2.62-Mev peak and peeled off throughout the entire spectrum. By this means the concentration of thorium in the sample was found to be 4.0×10^{-6} g per gram of soil. The spectrum remaining, also shown in Fig. 2, has lines at 1.76 and 2.17 Mev, both of which pertain to the uranium series; by a procedure identical with that used for the thorium series, but utilizing mock soil and carnotite, the spectrum due to uranium is normalized at these energies and peeled off. The uranium concentration was found to be 5.3×10^{-6} g per gram of soil. This left the K^{40} peak at 1.46 Mev to be com-

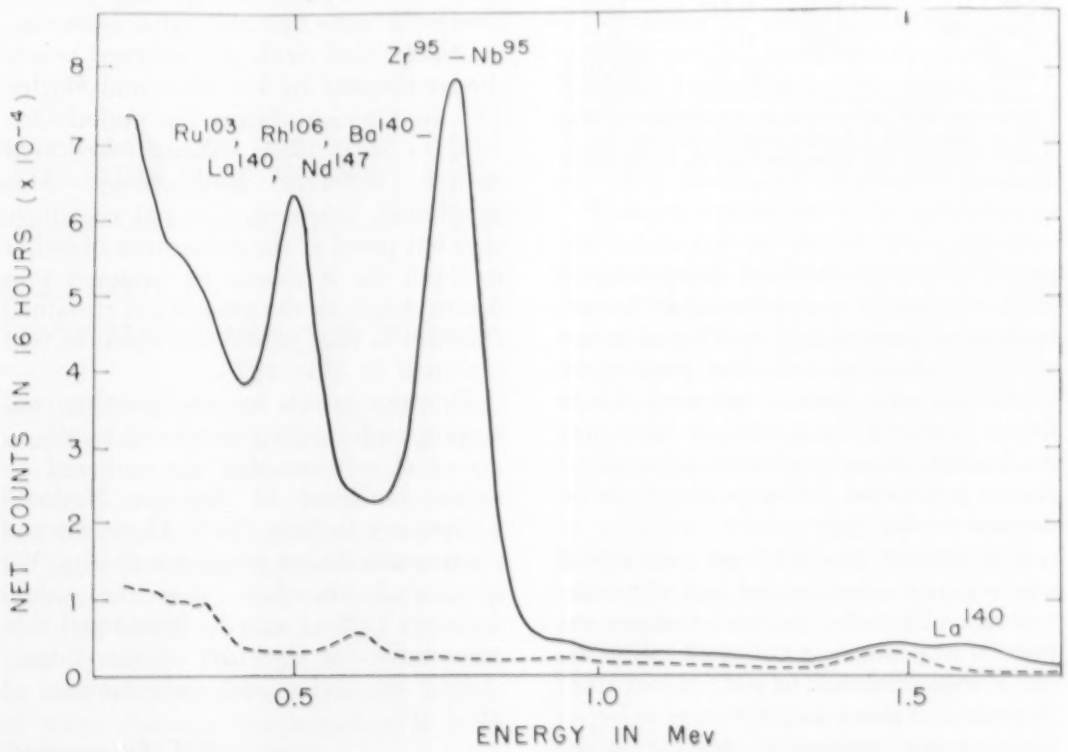

Fig. 1. Gamma-ray spectra of topsoil from Argonne National Laboratory (samples 1 kg each). (Solid line) Top 1.5 cm collected 2 Oct. 1957; counted 2 Oct. 1957. (Broken line) Top 2 in. collected 30 Aug. 1950; counted 3 Oct. 1957.

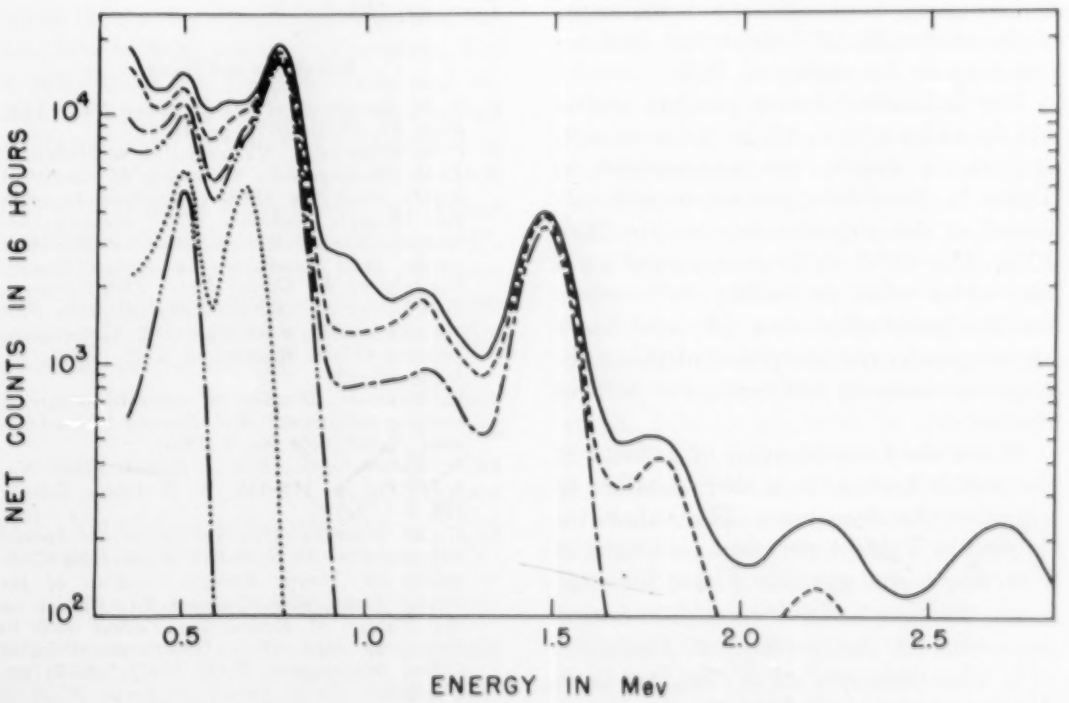

Fig. 2. Gamma-ray spectrum of top 1.5 cm of soil from Argonne National Laboratory (samples 1 kg each), collected 23 July 1957; counted 10 Oct. 1957. (———) Net spectrum (fission plus natural activities). (– – –) Fission products + K^{40} + U. (— – —) Fission products + K^{40}. (–· · —) Fission products only (· · ·) Ru^{103} + Rh^{103} + Cs^{137}. (— · · · —) Ru^{103} + Rh^{103}.

Table 1. Gamma-ray emitting radioactivity in the ground, and the dose therefrom, at Argonne National Laboratory as of May 1957 (sample series S_{II}).

Isotope	Radioactivity		
	mc/mi²	μr/hr	mr/yr†
U + daughters		4.02	35.21
Th + daughters		1.45	12.70
K^{40}		3.32	29.08
Zr^{95}-Nb^{95}	180	1.57*	3.45
Cs^{137}	35	0.12	1.08
Rh^{106}	175	0.23	1.47
Ru^{103}	175	0.50	0.70
Ce^{144}-Pr^{144}	240	0.09	0.37
Total		11.30	84.06‡

* Assuming Zr^{95}-Nb^{95} to be in equilibrium. † May 1957 to May 1958. ‡ In this total, 77 mr are due to natural activity, the remainder arising from fission products.

pared with that obtained from 1 kg of KCl, serving as a source of K^{40}; normalization showed 2.27×10^{-2} g of potassium per gram of soil. The peeling off of this spectrum leaves a spectrum due to fission products alone; this, in turn, may be broken down into the components due to individual fission products, as indicated in the figure.

Soil activity profiles were taken both where grassy cover existed and where the top soil was bare. Typical findings expressed as percentages of total fission activity, indicated that 62 percent occurred in grass and other vegetation growing or lying on the surface; 27 percent in the top 1½ in. of soil; 8 percent in the layer at a depth of 1½ to 3 in.; and the remaining 3 percent at 3 to 4½ in. Similar distribution was found in soil bare of vegetation. This profile study enabled us to take samples of sufficient depth to include essentially all fallout that had accrued up to the spring of 1957.

The individual fission product activities found in a 12 by 12 in. sector of soil, 4½ in. in depth, are summarized in Table 1; these data pertain to soil collected at the Argonne site in late May 1957. The Cs^{137} value is in rather good agreement with prevailing Sr^{90} values for this geographic area (*3*) and leads one to ponder the usefulness of this technique in assaying indirectly for Sr^{90} in the soil.

When the concentration of activity in the soil is known, it is then possible to calculate the dose rates. The values indicated in Table 1 pertain to a height of 3 ft above the ground. Those for uranium, thorium, and K^{40} were determined by means of the method of Hultqvist (*4*). The dose rate of 77 mr per year, due to natural radioactivity only, agrees well with results obtained by other methods (*5*) and offers evidence of the essential correctness of our nondestructive tests.

In the case of the dose due to fission activities, the approach of Dunning (*6*) was followed—namely, the assumption was made that fallout is limited to a thin, non-self-absorbing surface layer. These are, therefore, maximum values. The dose rates in microroentgens per hour shown in the second column of Table 1, will decrease markedly with time in the case of some of the fission products. In the absence of nuclear detonations, the fallout dose accumulated from May 1957 to May 1958 will be 7 mr at 3 feet above the ground. It is of interest to note that this value agrees remarkably well with the average yearly dose estimated by Eisenbud and Harley (*7*) for Chicago during the period Oct. 1952 to Sept. 1955, although they used entirely different methodology. This agreement, however, does not constitute rigorous proof of the correctness of either method, for it cannot be assumed that fission debris on the ground has remained constant in that period and equal to that obtained in May 1957.

In order to rule out any question concerning radioactivity produced locally, a group of soil samples was gathered 45 miles southwest of Argonne National Laboratory in July 1957. These showed comparable fission product activities. We concluded, therefore, that the values listed in Table 1 may be considered representative for this part of the country during the spring and early summer of 1957 (*8*).

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6. G. M. Dunning, *Hearings before the Special Subcommittee on Radiation of the Joint Committee on Atomic Energy, Congress of the United States, 85th Congress. First Session on the Nature of Radioactive Fallout and its Effects on Man.* (U.S. Government Printing Office, Washington, D.C., 1957), pt. 1, pp. 239–240.
7. M. Eisenbud and J. H. Harley, *Science* 124, 251 (1956).
8. The work described in this study was performed under the auspices of the U.S. Atomic Energy Commission.

13 January 1958

Visual Thresholds for Detecting an Earth Satellite

The visibility of an earth satellite of known stellar magnitude can be predicted from visual thresholds for point sources of light as measured by Blackwell (*1*) and by Knoll, Tousey, and Hulburt (*2*). The results of such calculations, together with a discussion of some problems encountered in searching for satellites, have been published by Tousey (*3*). This calculation was based on visual thresholds for a stationary point source of light seen against starless fields of different brightnesses. Real satellites, however, are in motion, and are often seen under full night conditions when the sky is filled with stars. For greater accuracy it was necessary to determine visual thresholds under the latter conditions.

A satellite simulator was constructed for this purpose. Satellites of stellar magnitude 2 to 10 were produced by an illuminated pin hole and collimator. The beam from the collimator was reflected into a viewing telescope by means of a rotating plane mirror driven by a cam and variable-speed drive. In this way the satellite could be made to move horizontally at any position across the field at angular rates characteristic of earth satellites at altitudes between 200 and 150 or more miles. Stars and a uniform sky background were introduced by reflection.

The results of the experiment are shown in Fig. 1, where the threshold magnitude of the satellite is plotted as a function of the background sky brightness. Threshold values are for a probability of detection of approximately 90 percent. The observations were made through an 8-power elbow telescope of 50 mm aperture and 53 percent transmittance. Curve *A* is the visual threshold relation for a stationary point source of light whose position in the field of view is known, calculated for this telescope from the data of Knoll, Tousey, and Hulburt (*2*). The simple theory, given by Tousey and Hulburt (*4*), indicates that this telescope increases the unaided eye threshold by 3.8 magnitudes, in proportion to the increased light entering the eye. The correctness of the theory and curve *A* were verified by using the satellite simulator to produce a stationary satellite which was viewed with and without the telescope against a field containing no stars.

Curve *B* is for a satellite moving in a star field. The altitude, magnitude, and angular velocity of a satellite crossing the meridian near zenith are related and are plotted on the ordinate scales of the figure for a specularly reflecting spherical satellite 20 inches in diameter. The subjects did not know where in the field of view the satellite would appear. How-

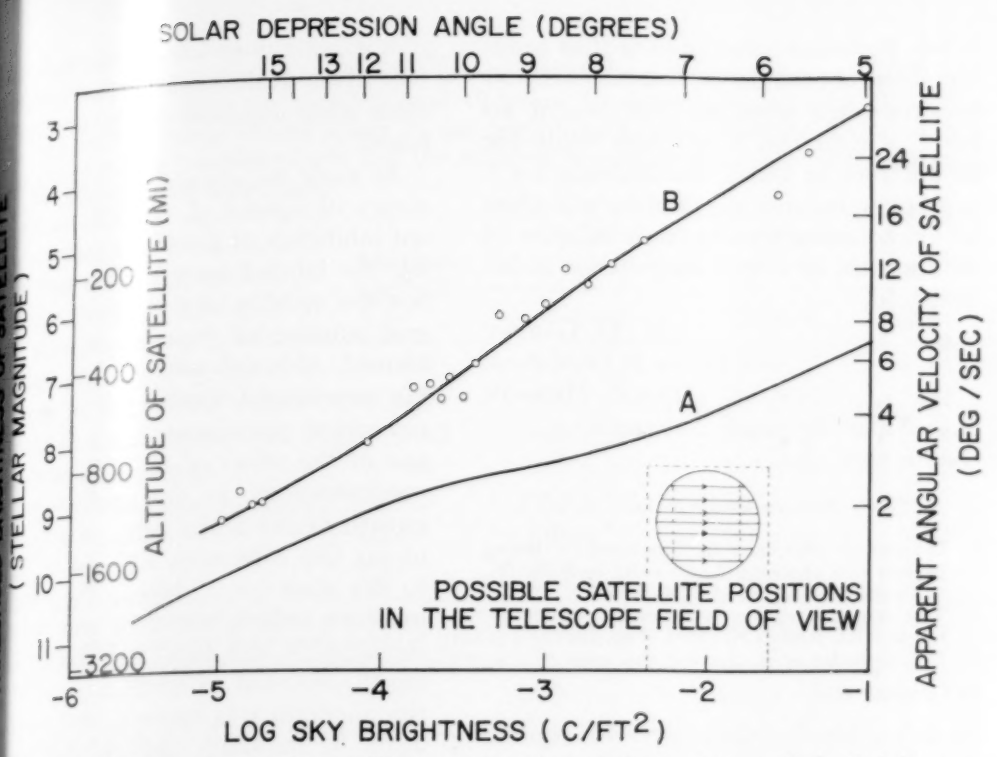
SOLAR DEPRESSION ANGLE (DEGREES)
15 13 12 11 10 9 8 7 6 5
THRESHOLD BRIGHTNESS OF SATELLITE (STELLAR MAGNITUDE)
3 4 5 6 7 8 9 10 11
ALTITUDE OF SATELLITE (MI)
200 400 800 1600 3200
APPARENT ANGULAR VELOCITY OF SATELLITE (DEG/SEC)
24 16 12 8 6 4 2
B
A
POSSIBLE SATELLITE POSITIONS IN THE TELESCOPE FIELD OF VIEW
-6 -5 -4 -3 -2 -1
LOG SKY BRIGHTNESS (C/FT²)

Fig. 1. Threshold magnitude of a satellite as a function of the background sky brightness.

ever, the satellite always traversed horizontally from left to right within the vertical limits set by an inscribed square.

It can be seen that the moving satellite, to be detected against a dark night sky with stars, must be approximately 1 magnitude brighter than for the stationary case with no stars in the background. This difference in threshold magnitudes begins to increase rapidly for skies brighter than 0.0002 ca/ft², where the changeover from rod to cone vision takes place. For 0.1 ca/ft², the highest sky brightness investigated, the difference reaches nearly 4 magnitudes.

The nature of these results can be explained qualitatively. At low field brightnesses, rod vision is used, and a satellite at threshold and at an unknown position can be detected almost equally well at any point in the visual field unless it lies on the fovea or the blind spot. Its presence is detected by its motion in the star field and it needs to be only 1 magnitude brighter than a stationary point of known position in a starless field. At high brightnesses, cone vision is used, and the threshold rises rapidly as the distance between the point of light and the point of fixation increases. Therefore, in effect, the satellite can be seen over only a small area surrounding the point of fixation. To have a reasonably high probability of detecting the satellite as it moves through a bright field, its brightness must be increased enough so that the area over which it can be seen at a single glance is fairly large.

Figure 1 can be used to obtain information of use in searching for spherical, specular satellites 20 inches in diameter. The scale of solar depression angle refers to the stage of twilight for which the sky within about 45° of the zenith has roughly the brightness shown by the scale at the bottom. For more details see Koomen *et al.* (*5*). The solar depression can be obtained with sufficient accuracy by linear interpolation between the times of sunset and the end of astronomical twilight, which are tabulated in the *Nautical Almanac*. The scale of altitude can be used without excessive error as a scale of slant distance for satellites seen as much as 45° from zenith.

As an example of the information given in Fig. 1, curve *B* indicates that a satellite at 200 miles altitude can be seen crossing the zenith, starting when the sun is 7.5° below the horizon and ending when the sun has set at the altitude of the satellite, in this case, 17° depression. For a satellite at 800 miles altitude and zenith, or at 400 miles altitude and zenith angle 60°, the sun must be depressed at least to 11°; however, sunset on a satellite at 800 miles altitude will not occur until the solar depression reaches 34°. Thus, high satellites can be seen well into full night, especially when they pass somewhat away from the zenith in the direction of the set sun.

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3. R. Tousey, *ibid.* **47**, 261 (1957).
4. R. Tousey and E. O. Hulburt, *ibid.* **38**, 886 (1948).
5. M. J. Koomen *et al.*, *ibid.* **42**, 353 (1952).

25 February 1958

Effect of Length of Observing Time on the Visual Threshold for Detecting a Faint Satellite

It is well known that the human observer performs at reduced efficiency when required to perform a difficult and uncertain visual task which extends over a considerable length of time. At a typical Moonwatch (*1*) station, to detect earth satellites, each observer looks through a low-power telescope fixed in position as part of an optical fence. He may be required to man the telescope for 2 hours or more during the entire twilight period favorable to seeing the satellite. Described in this report (*2*) is an investigation of the reduction of an observer's ability to detect a faint satellite after protracted observation periods.

Viewing conditions were simulated in the laboratory by use of the equipment described in a separate report (*3*). Looking through an 8-power elbow telescope, the observer saw a night-sky background with stars, across which the satellite traveled in 10 seconds, the speed appropriate to a 400-mile altitude.

Eight Naval enlisted men, well trained in observing with the simulator, served as subjects. Visual threshold measurements were made at the beginning and end of seven different observing periods ranging in length from 5 to 120 minutes. An additional watch period of 120 minutes during which the satellite did not appear was included early in the observing sessions to produce an uncertainty in the mind of the observer as to whether he would see the satellite at all.

For the initial, or "prewatch," threshold measurements, the position and time of appearance of the satellite were made known to the observer. For the watch periods, however, the observer was uncertain when and where the satellite would appear, if at all. His task was to observe continuously and, when he detected the satellite, to close a switch at the instant it crossed the eyepiece reticle.

The decrement in observer performance during watch was measured in terms of the difference between the prewatch and the watch thresholds. These differences for each observer are plotted in Fig. 1 against the duration of each watch. The mean curve is also shown. An ordinate value of +1 indicates that in order for the satellite to be detected, it was necessary to increase its brightness by one stellar magnitude, or a factor of 2.5 in luminosity, over that detected during prewatch observation.

It can be seen from Fig. 1 that the threshold after 5 and 15 minutes of watch was increased by 0.3 magnitude, on the average, over the prewatch value. From the absence of change between 5 and 15 minutes, it was concluded that the initial decrement was largely a result of

the fact that the subjects did not know exactly when and where the satellite was to appear.

For watch intervals beyond 15 minutes the decrement increased, reaching a maximum mean difference of 1.1 magnitude at 60 minutes. Observations at 90 and 120 minutes showed reduced mean decrements compared with the value at 60 minutes. The individual subjects, however, varied greatly in this respect, the greatest decrement occurring with S_4, and reaching 1.8 magnitudes at 60 minutes. Subjects S_5 and S_8, at the other extreme, showed very little decrement.

The group of points lying within the box labeled "observers warned that the satellite would appear" are data obtained after the observers had watched for 60 minutes as in other watch periods, but were then suddenly warned that the satellite would appear. These measurements were made to try to separate the decrement due to true fatigue from that caused by other factors. The small decrement was found not to be statistically reliable.

The conclusion reached from these results is that sometime between 15 and 30 minutes watch an additional decremental process sets in. This is distinct from the decrement due to space and time uncertainty and is caused by other factors which are associated with decreasing vigilance. The results obtained at 60 minutes with the observers warned show that this decrement was not caused by a true fatigue of the visual system.

A plausible explanation for the improvement in observer efficiency for watch periods longer than 60 minutes is that the observers knew that the longer they observed, the more probable it became that the satellite would appear.

It was found that training of the observers prior to the experiment resulted in an improvement in detection threshold, in some cases by as much as a magnitude. Training also reduced the number of false reports and the variability of individual thresholds.

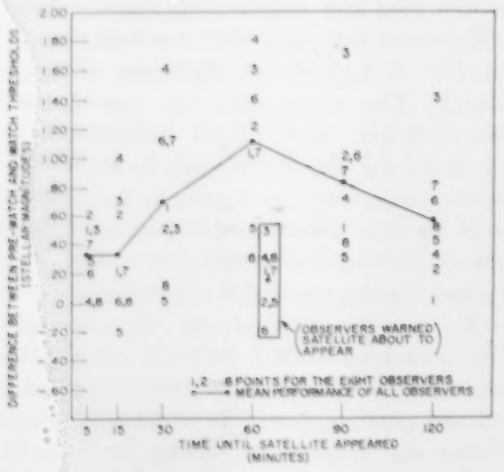
DIFFERENCE BETWEEN PRE-WATCH AND WATCH THRESHOLDS (STELLAR MAGNITUDES)
OBSERVERS WARNED SATELLITE ABOUT TO APPEAR
1,2 ... 8 POINTS FOR THE EIGHT OBSERVERS
MEAN PERFORMANCE OF ALL OBSERVERS
TIME UNTIL SATELLITE APPEARED (MINUTES)

Fig. 1. Decrement in detection threshold as a function of the observing times before the satellite appeared.

The practical conclusion is that satellite observers should be rotated every 30 minutes when possible. However, if no relief is available, it is worth while for an observer to watch continuously for 1 to 2 hours, because the satellite will often be bright enough to be seen in spite of the increase of 1 to 2 magnitudes in his threshold.

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1. Individuals who may be interested in taking part in this program should write to S. A. O., 60 Garden St., Cambridge 28, Mass.
2. This report has been published in greater detail as NRL Report No. 5094 (Feb. 1958).
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25 February 1958

Inhibition of HeLa Growth by Intranuclear Tritium

Tritium-labeled thymidine (H^3TDR) of high specific activity is proving to be a useful label for deoxyribonucleic acid (DNA). In conjunction with autoradiography, it has revealed the mechanism of duplication of genetic material (*1*, *2*) and the dynamics of cell renewal (*3*). As Robertson and Hughes have pointed out (*4*), such localization of tritium within the cell nucleus should result in almost exclusive irradiation of this radio-sensitive volume because of the very short range (average 1 μ, maximum 6 μ) of the resulting β-radiation. However, to date no evidence of radiation effects has been reported. This report demonstrates that high levels of incorporation of H^3TDR do cause radiation damage as predicted.

HeLa cells were grown in Eagle's basal medium (hereafter referred to as "standard medium") prepared in Hank's balanced salt solution, 20 percent horse serum and 15,000 units of penicillin, 1000 μg of Terramycin, and 5000 units of Mycostatin per 100 ml. The cells were inoculated into 1 ml of standard medium in Leighton tubes. Duplicate cell counts were made with hemacytometer chambers, observed at low (×100) power.

Tritium-labeled thymidine was prepared by catalytic exchange with CH_3COOH^3 and purified by column chromatography. It was homogeneous as judged by recrystallization with carrier thymidine and had a specific activity of approximately 500 mc/mole or about 2 mc/mg.

Incubation of HeLa cells for 24 hours with 2.5 μc/ml (about 1.25 μg/ml) of H^3TDR results in excellent labeling of the nucleus, as shown by autoradiography. Under these conditions, more than 100 silver grains appear over each nucleus after exposure of the film for 1 hours.

In early experiments testing the efficiency of uptake of H^3TDR, an apparent inhibition of growth of cells containing the labeled material was noted. To test the validity of this observation, several subsequent experiments were performed. Although alterations in design of the experiment were made in order to test other parameters, each included a test of the effect of H^3TDR, in various concentrations, in the medium on the growth of the HeLa cells. In all experiments the cells were allowed to attach to the glass for 3 days in the standard medium, which was then removed and replaced by the same medium containing the H^3TDR. After 24 hours at 37°C this medium was removed and replaced again by standard medium, and growth was allowed to continue for 48 more hours. The cells were then removed from the glass by incubating with trypsin, and total cell counts were made on triplicate samples (with the exception of experiment 2, in which six replications per treatment were used). Finally, an experiment was also performed to test the effect of chronic irradiation from tritium oxide (H^3_2O) in the medium. The results are summarized in Table 1.

The most important point to be noted is that, in all cases, the inclusion of H^3TDR in the medium resulted in inhibition of growth, except where carrier thymidine was added. The fact that the latter material reversed the action of H^3TDR demonstrates that the inhibition was a result of the intracellular incorporation of tritium and not some toxic contaminant. It is also of interest that each of the three levels of H^3TDR resulted in approximately the same extent of inhibition (the difference between the means of experiments 2A and 2B is not significant). These results indicate that thymidine concentration in the medium, at the levels used, exceeds the amount which the cells can accumulate and that the effect is a function of specific activity not concentration. This is consistent with autoradiographic observations where it appears that, in concentrations between 0.5 and 5 μc/ml, the amount of H^3TDR incorporated per cell is roughly the same.

The results of the last experiment illustrate that growth inhibition by H^3_2O is accomplished only by concentrations in the medium of 5 mc/ml or the order of 1000 times that at which H^3TDR exhibits its effects. However, if the difference in volumes which are under actual irradiation is considered, the dose to the nucleus is probably of about the same magnitude in both cases. To illustrate, in the experiment with 5 μc of H^3TDR per milliliter, only about 20 percent

Table 1. Inhibition of HeLa cell growth by inclusion of tritium in culture medium. In all experiments with thymidine, the cells were grown for 24 hours in the presence of H^3TDR, and then in colchicine medium for an additional 48 hours. In the experiment with H^3_2O, the cells were merely grown for 48 hours in the tritium-containing medium. Each control medium was same as treated except that the tritiated thymidine was replaced by an equal amount of nonlabeled thymidine.

Expt. No.	H^3 vehicle	Medium (μc/ml)	Total cell counts* at end of expt. (cell/μl)		
			Control	Treated	p†
1	Thymidine	2.5	170 ± 12	90 ± 17	< .01
2A	Thymidine	2.5	662 ± 38	357 ± 19	< .01
2B	Thymidine	1.25	662 ± 38	406 ± 43	< .01
3A	Thymidine	5.0	1333 ± 191	747 ± 60	< .05
3B	Thymidine + carrier‡	5.0	1333 ± 191	1124 ± 51	> .3
4A	H^3_2O	5000	696 ± 15	328 ± 65	< .01
4B	H^3_2O	1000	696 ± 15	633 ± 68	> .3

* Indicated values are means ± standard errors.
† Significance level for difference between means of treated and controls.
‡ 17.5 μg of additional unlabeled thymidine per milliliter.

μc) was incorporated. There were about 2.5×10^5 cells per milliliter at zero time in this experiment. The HeLa cell nucleus does not appear to exceed 15 μ in diameter, so that the maximum volume of the nucleus is 2×10^3 μ³. Therefore, the concentration of H^3TDR would be

$$1\ \mu c/2 \times 10^3 \times 2.5 \times 10^5\ \mu^3$$

or about 2×10^{-9} μc/μ³. In the experiment with H^3_2O, the concentration was 5 mc/ml, or 5×10^{-9} μc/μ³. This twofold difference is less than the error in our estimate of nuclear volumes. Therefore, the inhibition in this case, as in the case of external irradiation, can be reasonably attributed to nuclear damage caused by the β-radiation, and it is unnecessary to postulate special "hot atom" effects as used to explain the toxicity of P^{32} incorporated into the DNA of bacteriophage (*5*) or bacteria (*6*). It is of interest that 5 mc/ml of H^3_2O (the concentration of H^3_2O required for growth inhibition of HeLa cells) was found to reduce the mitotic index in regenerating liver by about 50 per cent (*7*). Water containing 5 mc/ml of tritium irradiates itself at the rate of 65 rep/hr.

These results imply upper limits of labeling for tracer applications of tritium. At the moment these limitations do not appear to be too stringent, for cells labeled at an inhibitory level reduce hundreds of silver grains per week, whereas a few grains per month are quite satisfactory for autoradiography. Nevertheless, the fact that the other radiobiological phenomena, such as chromosome breaks, mutations, and cancerogenesis, occur at much lower radiation levels than needed for gross inhibition of cell division should be borne in mind when interpreting results. The fact that tritium-labeled thymidine concentrates radioactivity in radiosensitive regions where it may remain a long time also demands extra caution in its handling. The radiotherapeutic possibilities of tritium incorporated within the nucleus are being further pursued (*8, 9*).

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5. A. D. Hershey *et al.*, *J. Gen. Physiol.* **34**, 305 (1951).
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8. This research was supported by the U.S. Atomic Energy Commission.
9. We acknowledge the excellent technical assistance of Bernice Giauque.

20 December 1957

Formula for Inferring Atmospheric Density from the Motion of Artificial Earth Satellites

A simple formula for inferring air density from satellite motion may be useful to workers in the field (*1*). To find such a formula, the density, ρ, is approximated near perigee by $\rho_\pi e^{-Kz}$, where ρ_π is the density at perigee, z is the altitude above perigee, and K is the logarithmic gradient of density

$$K = -2.3026\ (\mathrm{d}/\mathrm{d}z)\ \log_{10}\rho \qquad (1)$$

at perigee. An integral that appears in a basic analysis (*2*) of orbital effects of drag is then evaluated in terms of Bessel functions $I_0(Kae)$ and $I_1(Kae)$, where a is the orbital mean distance and e the eccentricity. The Bessel functions are expanded asymptotically, and there finally results an approximate formula by which ρ_π may be inferred from the rate of change, $\dot{P}$, of the period P and from certain other data. In practical units the formula is

$$\rho_\pi = -4.826 \times 10^{-15} \times \dot{P}\,\frac{m}{AC_D}\,\frac{c^{1/2}}{af(c,e)}\ \mathrm{g/cm^3} \qquad (2)$$

where $\dot{P}$ is in seconds per day; m is the satellite's mass in grams; A is the satellite's area in square centimeters projected on a plane normal to the direction of motion; C_D is the dimensionless aerodynamic drag coefficient, believed to be approximately 2; a is measured in earth radii of 6378 km; c is 6378 Kae if z, in Eq. 1, is in kilometers; and $f(c,e)$ is a function given approximately by

$$f(c,e) = 1 + 2e + (3e^2/2) + \frac{1 - 6e - 10.5e^2}{8c} + \frac{9 + 30e + 85.5e^2}{128c^2} + \ldots \qquad (3)$$

The first two terms alone in Eq. 3 appear to furnish the function to within an accuracy of about 10 percent, and the whole expression, to within a few percent, if e lies between 0.02 and 0.20 and K exceeds 0.01. The mean distance a may be inferred from P, and e and ae from a and r_π, the geocentric perigee distance in earth radii, by the equations:

$$a = (P/84^m.49)^{2/3}$$
$$e = 1 - r_\pi/a$$
$$ae = a - r_\pi$$

The numerical coefficient in Eq. 2 is the reciprocal of $3(\pi/2)^{1/2}$ times the number of seconds in a day times the earth's radius in centimeters. An average value of the A of a nonspherical satellite should be used in Eq. 2, and if all orientations are equally frequent and the satellite is convex, its average A is one-fourth of its total superficial area. The value of K, somewhat dependent on perigee height, can be approximated by applying Eq. 1 somewhat above perigee to a model atmosphere like the ARDC (*3*). Alternatively, K may be determined without reference to assumed models by applying Eq. 2 to two or more satellites with different perigee heights and adjusting K until it is consistent with the resulting perigee densities.

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References and Notes

1. I am indebted to Dr. G. F. Schilling for pointing out the utility of a simple, approximate, formula.
2. T. E. Sterne, *Astron. J.*, in press.
3. R. A. Minzner and W. S. Ripley, "Air Research and Development Command (ARDC) Atmosphere," *ASTIA Document 110233* (1956).

14 March 1958

Meetings

Preliminary Announcement of Washington Meeting and Call for Papers by AAAS Sections

From the programs and other events already in an advanced stage of planning, it is apparent that the 125th meeting of the American Association for the Advancement of Science, 26–31 Dec., will be well balanced, particularly well attended, and especially significant. This annual meeting for the year 1958 will also be the seventh Washington meeting.

Unlike the previous AAAS Washington meeting of September 1948, when the Association celebrated its centenary without participating societies and with no commercial exhibits, this year's meeting will be similar in pattern to those of recent years.

The programs of the 18 AAAS sections will cover the principal fields of science, and some 44 organizations will have their own sessions. Included are 13 national meetings—notably those of the American Astronautical Society, the American Society of Zoologists, the Society of Systematic Zoology, the History of Science Society, and the science teaching societies—and special or regional meetings of 31 societies. Among this latter group are societies not previously represented, such as the American Society of Photogrammetry, the Instrument Society of America, and the Washington Academy of Sciences. Many of the more than 300 sessions will be cosponsored by an additional 40 or more societies.

Among the highlights of the Washington meeting will be a five-session symposium commemorating the Linnaean Bicentennial, sponsored by the Society of Systematic Zoology and cosponsored by the Systematic Section of the Entomological Society of America, the American Society of Plant Taxonomists, and others, and the three sessions devoted to the International Geophysical Year. There will be distinguished evening addresses sponsored by the Scientific Research Society of America, the Society of the Sigma Xi, and the United Chapters of Phi Beta Kappa, and the National Geographic Society will present another of its uniformly excellent illustrated lectures.

The Association as a whole—in addition to its business sessions, the retiring presidential address of Laurence H. Snyder, a reception, and a smoker—will have a two-session general symposium, "Moving Frontiers of Science III," concerned with the comparative structure of science and scientific organizations throughout the world. The problems in science and education that confront the nation at the present time will be reflected in a number of the programs. The Association's Committee on the Social Consequences of Science is considering presentation of a two-day program devoted to air and water pollution.

Thus this 125th meeting will be consistent with the fundamental, original purpose of the Association as set forth when it was founded in September 1848: ". . . by periodical and migratory meetings to promote intercourse between those who are cultivating science." At the same time, current matters of great concern will not be neglected. The annual meeting is a major activity of the Association. Now, with 279 affiliates and a membership approaching 60,000, the AAAS more than ever is prepared to consider matters that affect all scientists and society. In recent years the Association has also increasingly recognized its responsibility to inform the general public on developments in science and its obligation to help strengthen the nation's educational system.

The significance of the seventh Washington meeting has already been recognized by those who produce the books, instruments, and materials which scientists and teachers use. Applications for exhibit booths have been received at a most gratifying rate. The 1958 version of the Association's Annual Exposition of Science and Industry will be one of the most complete and attractive ever staged. It is probable that supplemental space will have to be used for the special exhibits that governmental agencies and nonprofit organizations have expressed a wish to show. Fortunately, such space is available, on the approaches to the exhibit hall. Incidentally, the exposition is *not* intended for young people below the college level—most of the exhibits would be too technical. (The Association, to meet the interests of younger students of science, annually arranges a Junior Scientists Assembly, at which eminent scientists address a large audience of high school students on aspects of science and scientific careers.)

Center of the meeting and AAAS Headquarters will be the attractive Sheraton-Park Hotel, which will accommodate the larger sessions, the Annual Exposition of Science and Industry, the AAAS Main Registration-Information Center, the AAAS Pressroom, the AAAS Office, and the AAAS Science Theater. This hotel's large ballroom will be the site of the AAAS Smoker for all registrants, on the evening of 29 Dec.

Other hotels will be the headquarters of related sections and societies—the Shoreham, for example, will house the science teaching societies. Hotel headquarters assignments in the Dupont Plaza, Roosevelt, Sheraton-Carlton, and Statler, in the Hotel Twenty-four Hundred, and in the Washington, Willard, Windsor Park, and Woodner will be announced in July, when the advertising pages of *Science* will begin to carry coupons for housing reservations and advance registration. As usual, advance registrants will receive the book-size General Program-Directory early in December, by first-class mail.

Local committees. No AAAS meeting could succeed without the interest and substantial assistance of local members and friends of the Association. General chairman of the seventh Washington meeting is Leonard Carmichael, secretary of the Smithsonian Institution, which generously housed the AAAS for many years prior to 1946. Carmichael's appointments will be announced in a subsequent issue.

Programs. A synopsis of the program, arranged by disciplines, follows. The names given within parentheses are section and society officers or program chairmen.

Mathematics (A)

The program of *Section A* (C. C. MacDuffee, University of Wisconsin) will begin at 4 P.M. on the afternoon of 26 Dec. with the vice-presidential address, "Recent developments in topological and analytical dynamics," by G. A. Hedlund, Yale University. A group of invited papers on "Mathematics for the Social Scientists"—probably a joint presentation with the Operations Research Society of America—is scheduled for the morning of 27 Dec. A panel discussion on "The Problem of Formulating a Problem," under the leadership of Richard Burington, Naval Ordnance, which will also be of interest to those who work in applied mathematics and peripheral areas, will be held the morning of 29 Dec.

The recently affiliated *Association for Computing Machinery* (Jim Dougla

Mathematics Department, Rice Institute) will hold one of its two annual national meetings with the AAAS in Washington.

Physics (B)

Section B (J. Howard McMillen, National Science Foundation) will hold a three-session symposium, "Recent Advances in Physics," from the afternoon of 28 Dec. through 29 Dec. Topics and speakers will include: "Effects of lightning on trees and buildings," by Francis Defandorf, National Bureau of Standards; "Elementary particles," by Maurice Shapiro, Naval Research Laboratory; "The properties of positronium," by Richard Ferrell, University of Maryland; and "The present status of relativity theory," by Joseph Weber, University of Maryland. At the physicists' luncheon, which Section B will sponsor jointly with the *American Association of Physics Teachers, Chesapeake Section,* Raymond T. Birge, University of California, Berkeley, will give the retiring vice-presidential address of the section and Robert Bruce Lindsay, Brown University, will serve as toastmaster.

Previously unrepresented at AAAS meetings, the recently affiliated *American Astronautical Society* (Ross Fleisig, 516 Fifth Avenue, New York 36), will hold its fifth annual meeting with the AAAS. There will be some three days of sessions for invited and submitted papers on aspects of space science, grouped by subject.

The *American Meteorological Society* (Kenneth Spengler, AMS, Boston) will cosponsor appropriate sessions and plans to have several sessions of its own.

Chemistry (C)

The program of *Section C* includes a three-session symposium on "Chemical Effects of High Energy Radiation" (Leo A. Wall, National Bureau of Standards) with Wall, Milton Burton (University of Notre Dame), and S. D. Bailey (Quartermaster Research and Development Center) as discussion leaders; a two-session symposium, "Frozen Free Radicals" (F. O. Rice, Chemistry Department, Catholic University of America); and a third symposium, "Gas Phase Reaction Kinetics" (Ralph Klein, National Bureau of Standards), to be held within the period 27–30 Dec. At the chemists' dinner, 29 Dec., F. O. Rice will give the vice-presidential address of Section C. There will also be sessions for contributed papers.

Alpha Chi Sigma, Washington Professional Chapter (Andrew F. Freeman, U.S. Department of Agriculture, Washington, D.C.) will give a chemists' luncheon and will present an address for all chemists.

The *American Association of Clinical Chemists* (Elizabeth G. Frame, Clinical Center, National Institutes of Health, Bethesda, Md.) will have a symposium, sessions for contributed papers, and a dinner with a speaker.

Astronomy (D)

Section D (Frank K. Edmondson, Goethe Link Observatory, Indiana University) is organizing a symposium on celestial mechanics, which, together with the retiring vice presidential address by Chester B. Watts, U.S. Naval Observatory (Dirk Brouwer, Yale University, presiding), will be held early in the meeting period so that astronomers may also attend the American Astronomical Society meeting in Florida.

The *Astronomical League* (Grace C. Scholz, 410 Mason Hall Apartments, Alexandria, Va.) will have a day of sessions.

Geology and Geography (E)

The program of *Section E* (Frank C. Whitmore, Jr., U.S. Geological Survey, Washington, D.C.) includes a two-session symposium (27 Dec.) on the history of geology, cosponsored by Section L; contributed papers on geology and geography (28 Dec.); and two two-session symposia on 29–30 Dec., one of them, "Multiple Glaciations," arranged by Richard J. Lougee, of Clark University. As usual, the *Geological Society of America* will cosponsor all geologic sessions, including the Section E smoker, 27 Dec., at which the retiring vice-presidential address of Robert R. Shrock, Massachusetts Institute of Technology, will be given, with Byron N. Cooper, Virginia Polytechnic Institute, presiding. In addition, Section E will cosponsor the symposium of Section O and the program of the American Society of Photogrammetry.

The *Association of American Geographers, Middle Atlantic Division* will cosponsor the geographical sessions of Section E and will have a two-session symposium of its own, 27 Dec.

The *National Speleological Society* (William E. Davies, U.S. Geological Survey, Washington, D.C.) will have two sessions for contributed papers, principally on biology, and a symposium on karst phenomena, cosponsored by Section E. The *National Geographic Society* will have its usual outstanding lecture and accompanying film, probably on the evening of 30 Dec.

Zoological Sciences (F)

The program of *Section F* (Karl M. Wilbur, Department of Zoology, Duke University) will be coordinated with the national meetings of the American Society of Zoologists and the Society of Systematic Zoology. It will consist of one or more symposia, such as "Unsolved Problems in Biology III," and the cosponsorship of appropriate sessions. At the zoologists' dinner, presented jointly with the zoological societies, the vice-presidential address of the section will be given by Harold H. Plough, Amherst College.

The national meeting of the *American Society of Zoologists* (Sears Crowell, Indiana University)will include a three-session symposium on vertebrate morphology, arranged by Alfred Romer; a two-session symposium on arthropod physiology; a series of sessions for contributed papers; the cosponsorship of appropriate programs; and the annual business meeting.

The *Society of Systematic Zoology* (G. W. Wharton, Department of Zoology, University of Maryland) will celebrate the occasion of its tenth annual meeting and commemorate the 200th anniversary of the publication of the tenth edition of Linnaeus' *Systema Naturae* with a program of special interest to all systematic biologists. The theme will be "The Linnaean Bicentennial: 200 Years of Progress in Systematics." The following symposia and panel discussions are planned: (i) "Linnaeus and Nomenclatorial Codes," including Linnaeus' contributions to systematic biology, the botanical code, the microbiological code, and the zoological code; (ii) "Biological Bases of Linnaean Concepts" (this symposium, arranged by Alfred Emerson, Society of Systematic Zoology, will stress biological rather than historical or nomenclatorial subjects); (iii) "Systematics—Present and Future," including the status of systematic botany, the status of systematic zoology, the future of systematic botany, and the future of systematic zoology; (iv) a panel discussion on the London Congress and zoological nomenclature (Curtis Sabrosky will lead a discussion of the new code to be adopted at London, and panel members will be drawn from among systematists who attend the London Congress); (v) a summary panel: each of the preceding symposia will be summarized, and a panel composed of those who have spoken previously will discuss questions that have arisen in the course of the presentations. Cosponsors of the foregoing program include AAAS Sections F and G, the American Society of Zoologists, *Entomological Society of America, Association of Southeastern Biologists, Society for the Study of Evolution, American Ornithologists' Union, American Society of Mammalogists, American Society of Ichthyologists and Herpetologists,* and the *American Society of Plant Taxonomists.*

The Society of Systematic Zoology will also have sessions for contributed papers, a dinner, and a business meeting and will cosponsor a biologists' smoker early in the meeting period. Another feature will be the annual SSZ Library and Lounge for all zoologists.

Biological Sciences (FG)

Between biennial meetings, *Beta Beta Beta Honorary Biological Society* (Mrs. Frank G. Brooks, Box 336, Madison Square Station, New York 10) will hold a meeting of its study committee with the AAAS, 27 Dec. It is anticipated that the *Ecological Society of America* (John H. Davis, Jr., Department of Botany, University of Florida), will have its usual regional meeting with the Association, with sessions for contributed papers and cosponsorship of appropriate programs.

The annual national meeting of the *National Association of Biology Teachers* (Paul Klinge, Jordan Building, Indiana University) will begin with business meetings 26 Dec. During the meeting period there will be a luncheon, a joint meeting with the American Nature Study Society, the National Association for Research in Science Teaching, and the National Science Teachers Association (28 Dec.), and a series of separate sessions. A field trip with the American Nature Study Society, 30 Dec., will conclude the program. The *Biometric Society, ENAR* (Jerome Cornfield, Division of Research Services, National Institutes of Health) is planning a joint program with the American Statistical Association that will not conflict, in time, with the society's national meetings in Chicago. It is expected that the *American Society of Naturalists* (Bruce Wallace, Biological Laboratory, Cold Spring Harbor, N.Y.) will either arrange a symposium or cosponsor one in the F, FG, or G series.

Botanical Sciences (G)

In addition to the symposium "Some Unsolved Problems in Biology III," held jointly with Section F, *Section G* (Barry Commoner, Henry Shaw School of Botany, Washington University) will have sessions for contributed papers in the principal fields of botany; these will probably be cosponsored by the *American Society of Plant Physiologists,* the Ecological Society of America, and others. Other symposia are planned, and, following the annual botanists' dinner, the vice-presidential address of Section G will be given by Oswald Tippo, Yale University.

Anthropology (H)

The plans of *Section H* (James L. Giddings, Haffenreffer Museum, Mount Hope Grant, Bristol, R.I.) are yet to be announced but probably will include a symposium and one or more vice-presidential addresses.

Psychology (I)

Section I (Clifford T. Morgan, Town Point, Cambridge, Md.) will have six sessions of invited papers covering the principal areas of research activity in psychology. The vice-presidential address will be given by B. F. Skinner, Harvard University.

Social and Economic Sciences (K)

Section K will have a symposium on "Research Problems in the Social Sciences"; in addition, the *National Academy of Economics and Political Science* (Donald P. Ray, George Washington University), the *American Economic Association,* and Section K, on the evening of 27 Dec., will jointly sponsor a symposium on "Major Problems of the American Economy." This will include the vice-presidential address of Joseph J. Spengler, Duke University. It is anticipated that *Pi Gamma Mu,* the national honorary society in the social sciences, will have a dinner for the speakers. In addition, Section K will cosponsor appropriate programs of the K series and will again sponsor sessions for contributed papers in the social and economic sciences.

The *AAAS Committee on the Social Consequences of Science* (Chauncey D. Leake, Ohio State University College of Medicine) is planning a four-session symposium on "Pollution of Airs and Waters."

The *American Society of Criminology* (Donal E. J. MacNamara, New York Institute of Criminology) will have a four-session symposium, "Controversial Areas in 20th Century Criminology," 27–28 Dec., and a luncheon with speakers. Among the "controversial areas" which will be discussed are criminal somatotyping, delinquency prediction techniques, legalization of gambling, integration of small police units, graphological diagnosis or identification of personality defects and criminal tendencies, hypnosis and crime, personnel screening techniques, crime and delinquency statistics, and the certification or licensing of practitioners in criminological and allied fields. Cosponsors of the program are the *Association for the Psychiatric Treatment of Offenders, Institute for Research on Crime and Delinquency, New York Institute of Public Service Training, New York Institute of Criminology,* and *Character Underwriters Inc.*

The *American Political Science Association* (Evron M. Kirkpatrick, APSA, Washington, D.C.) is considering sponsoring a special program jointly with Section K.

The *American Sociological Society* (Kingsley Davis, Institute of International Studies, University of California, Berkeley) plans a special meeting with the AAAS. One symposium, "Demographic and Sociological Aspects of Scientific Manpower," 27 Dec., arranged by Theodore Caplow, University of Minnesota, may include papers on the changing prestige and reward system of the learned occupations in America, the medical profession and scientific ... power (a comparative analysis of ... occupational relations), professional ... power allocation in the Soviet Union ... and a sociological analysis of the ... sons for deficient scientific education ... American schools.

A second symposium, "Sociologic... Studies of Mental Disorder," chair... jointly by A. B. Hollingshead and Jero... K. Myers of Yale University, may ... clude papers on sociological aspects ... alcoholism in the United States, the ... cial structure of institutions for men... care, statistical problems in measur... the incidence and prevalence of men... disorder, social stratification and schi... phrenia, and new departures in medic... sociology with particular reference ... mental health.

The *American Statistical Associat...* (Ezra Glazer, 305 E. George Mas... Drive, Falls Church, Va.) will have ... regional meeting of particular interest ... local statisticians in both the physic... and biological sciences.

The *Metric Association* (J. T. Joh... son, Claremont, Calif.) plans a joint pr... gram with Section C.

History and Philosophy of Science (L)

The program of *Section L* (John W... Streeter, Franklin Institute, Philade... phia), coordinated with the nation... meeting of the History of Science So... ciety, will include a symposium on com... munications, joint with the Conferenc... on Scientific Communication Problem... a second symposium on free fall or th... concept of space, possible sessions fo... contributed papers, and a business mee... ing. The vice-presidential address of Ca... B. Boyer, Brooklyn College, will be give... at a dinner, sponsored jointly with th... History of Science Society. Section ... will cosponsor appropriate portions ... the society's program and Section E ... "History of Geology" symposium.

The annual national meeting of th... *History of Science Society* (Morris ... Leikind, Armed Forces Institute of P... thology, Washington, D.C.) will includ... a symposium on the progress of the hi... tory of science in America, another o... recent studies of pre-Darwinian evolu... tion, one or more sessions for contribute... papers, one or more luncheons or din... ners, and a business meeting.

It is anticipated that the *Philosophy of Science Association* (C. West Church... man, Case Institute of Technology) wi... have a multisession symposium. Th... *Society for General Systems Researc...* (Richard L. Meier, Mental Health Re... search Institute, Ann Arbor, Mich.) wi... hold its annual meeting with the AAA... One session will be a symposium, "Popu... lation Dynamics for Humans, Organ... isms, and Concepts," held on the morn...

of 29 Dec., arranged by Kenneth E. ulding, University of Michigan; the rnoon session, following an infor- luncheon, will be for contributed pers.

ineering (M)

Section M will have a two-session sym- um, "National and International As- ts of the Systems of Units of Science Technology," arranged by a com- tee (Carl F. Kayan, College of Engi- ring, Columbia University, chair-); it will cosponsor other appropri- programs.

The *Engineering Manpower Commis-* will cosponsor the sessions of the ference on Scientific Manpower.

Two affiliated societies which have not ticipated previously in AAAS meet- have arranged special sessions: The erican Society of Photogrammetry ichard G. Ray, U.S. Geological Sur- Washington, D.C.) plans to hold a o-session symposium, 29 Dec., cospon- ed by Section E and other appropriate tions, on applications of photogram- try in different disciplines. The *In- ment Society of America* (Orval L. nebrink, Battelle Memorial Institute) scheduled a symposium, "Instrumen- ion of Precision Measurement," for afternoon of 29 Dec.

dical Sciences (N)

As in previous years, *Section N* will a four-session symposium, with par- pants coming from all parts of the tinent and, probably, with one or e speakers from abroad. This year's ject is "Congenital Heart Disease." symposium, arranged by a commit- (Gordon K. Moe, State University of York Medical Center, Syracuse, irman), will include papers on em- ology and prenatal influences, pathol- biochemistry physiology, diagnosis, the latest treatments; included will the vice-presidential address of Moe the announcement of the 14th Theo- Smith award, given by Eli Lilly and pany. Section N will also cosponsor riety of appropriate programs.

Alpha Epsilon Delta (Maurice L. re, national secretary) will devote sual morning session to the subjects premedical and predental education. session will be held 27 Dec., at rge Washington University School of dicine. The annual luncheon, with a ker of prominence, and informal erences will conclude the day's ac- ties.

The *American Psychiatric Association* J. West, University of Oklahoma ol of Medicine) will have its usual ial meeting with the AAAS—de- d, this year, to a four-session sym- um in some area of neurophysiology. Details of the program of the special tings of the *American Association of Hospital Consultants* (John C. MacKenzie, Touro Infirmary, New Orleans) and the *American Physiological Society* (Fred A. Hitchcock, Ohio State University) are not yet available.

Dentistry (Nd)

The two-session symposium of *Section Nd* (Reidar F. Sognnaes, Harvard School of Dental Medicine), on "Calcification in Biological Systems," to be held 29 Dec., will include the following papers and speakers: "Calcification in representative invertebrates with special reference to crustaceans," Dorothy F. Travis, University of New Hampshire; "Mineralization mechanism in the exoskeleton of molluscs and echinoderms," Gerrit Bevelander, New York University; "Mineral deposition in cartilage," Richard Follis, Armed Forces Institute of Pathology; "Relation of organic and inorganic elements of bone," Robert R. Robinson, Johns Hopkins University; "Dental aspects of mineralization," Reidar F. Sognnaes, Harvard University; "Discussion of physiological calcification mechanisms; pathological calcification," George M. Hass, Presbyterian Hospital, Chicago; "Salivary calculus deposition," S. Wah Leung, University of Pittsburgh; "Mineral nucleation on reconstituted collagen in vitro," Melvin I. Glimcher, Massachusetts Institute of Technology; and "Behavior of bone in tissue culture," Paul Goldhaber, Harvard University. The symposium will conclude with a general discussion and a general summary. The program of the section will be cosponsored by the *American College of Dentists*, the *American Dental Association*, and the *International Association for Dental Research, North American Division*.

Pharmacy (Np)

The three-day program of *Section Np* (John E. Christian, School of Pharmacy, Purdue University) begins 27 Dec. with a morning session for contributed papers on hospital pharmacy and continues with symposia on "The Hospital Pharmacist of the Future" and "Advances in Conquering Cancer," arranged by George F. Archambault, U.S. Public Health Service, Washington, D.C., and Joseph Oddis, American Hospital Association, Chicago. Other sessions, for contributed papers, are scheduled for the evenings of 27 and 29 Dec. There will be a pharmacists' dinner, a vice-presidential address by Archambault, and tours of the Clinical Center, National Institutes of Health, and the American Pharmaceutical Association. Section Np's entire program will be cosponsored by the *American Association of Colleges of Pharmacy, American College of Apothecaries, American Society of Hospital Pharmacists, American Pharmaceutical Association*, and *National Association of Boards of Pharmacy*.

Agriculture (O)

Section O (Roy D. Hockensmith, Soil Conservation Service, U.S. Department of Agriculture, Washington, D.C.) will have a four-session symposium on "Water and Agriculture," 29–30 Dec. Among the subjects and speakers are the following: (Part I) "Water for the future: water resources planning and development in agriculture," Edward A. Ackerman, Resources for the Future, Inc., Washington, D.C.; "Legal aspects of water use in agriculture," Clarence A. Davis, Washington, D.C.; "Significance of small watershed programs to American agriculture," Carl B. Brown, Soil Conservation Service, Washington, D.C.; "Changing groundwater conditions and their impact on agriculture," R. L. Nace, U.S. Geological Survey, Washington, D.C. (Part II) "Water sources: factors that affect the water cycle," William C. Ackerman, Illinois State Water Survey Division; "The effects of weather modification on water supplies," Howard T. Orville, Beckman & Whitley, Inc., Long Green, Md; "Use of climatic data in guiding farming operations," C. H. M. Van Bavel, Agricultural Research Service (ARS), North Carolina State College; "Precipitation measuring and analyses as an aid to agriculture," Gerald L. Barger, Weather Bureau, Ashville, N.C. (Part III) "Water planning and use: relations between soil conservation practices and the availability of water for agriculture," Cecil H. Wadleigh, ARS, Beltsville, Md.; "Increasing water yields by forest management," Herbert C. Storey, U.S. Forest Service, Washington, D.C.; "Interdependence of upstream and downstream water management," Wayne D. Criddle, Utah State Engineer, Salt Lake City; "Views of water users in federal reclamation projects," William I. Palmer, U.S. Bureau of Reclamation, Washington, D.C. (Part IV) "Water control: drainage problems on agricultural lands," T. W. Edminster, ARS, Beltsville, Md.; "Control of aquatic vegetation and phreatophytes," F. L. Timmons, ARS, Laramie, Wyo; "Suppressing evaporation for water surfaces," G. Earl Harbeck, Jr., U.S. Geological Survey, Denver, Colo.; "Energy balance approach to evapotranspiration from crops," C. B. Tanner, University of Wisconsin. At the end of each session there will be a period for discussion after presentation of the papers. Discussion leaders include Bernard Frank (U.S. Department of Agriculture, Washington, D.C.), Kenneth C. Spengler (American Meteorological Society), William G. McGinnies (Central States Forest Experiment Station, Columbus, Ohio), and Waldo E. Smith (American Geophysical Union).

This symposium will be cosponsored

by Section E and the American Geophysical Union, American Meteorological Society, *American Society of Agricultural Engineers, American Society of Civil Engineers, American Society of Agronomy, American Society for Horticultural Science, Gamma Sigma Delta,* Geological Society of America, *Society of American Foresters,* and *Soil Conservation Society of America.*

Industrial Science (P)

The program of *Section P* (Allen T. Bonnell, Drexel Institute of Technology) will include, on 29 Dec., a symposium on "Industrial Science Today," of particular interest to leaders in industry. This will be followed by a luncheon at which the retiring vice-presidential address of Frank C. Croxton, Battelle Memorial Institute, will be given. The final session will be the third Industrial Citation Dinner.

The *Society for Industrial Microbiology, Washington Section* (Walter N. Ezekiel, Bureau of Mines, Washington, D.C.) will have a symposium cosponsored by Section P and one or more sessions for contributed papers.

Education (Q)

The program of *Section Q* (Herbert A. Smith, University of Kansas) inclu two joint sessions with the *Internati Council for Exceptional Children,* Dec.; two sessions, joint with the *Am ican Educational Research Associati* 30 Dec.; four sessions for contribu papers, 29–30 Dec.; and a business me ing and the vice-presidential address Harry A. Cunningham, Kent State U versity, 29 Dec. The *AAAS Cooperat Committee on the Teaching of Scie and Mathematics* (Bernard B. Wats 2806 Blaine Drive, Chevy Chase, M will cosponsor the National Associat for Research in Science Teaching p gram.

The four science teaching socie meeting with the AAAS (coordinat Robert H. Carleton, Executive Sec tary, National Science Teachers As ciation, Washington, D.C.) will have joint mixer the evening of 27 Dec. T joint session the morning of 28 Dec. w be devoted to the findings of the In national Geophysical Year.

The separate portions of the progr of the regional meeting of the *Natio Science Teachers Association* (Willi A. Kilgore, D.C. Teachers Colle Washington, D.C.) consists of a meet of the executive committee and two s sions on 27 Dec. and three other sessi on 28 and 29 Dec., the one on eleme tary science joint with the Americ Nature Study Society. Tours to the N tional Institutes of Health, the Bure of Standards, and the Agricultural R search Center are scheduled for t morning of 29 Dec.

The *National Association for R search in Science Teaching* (Ellswo S. Obourn, U.S. Office of Educati Washington, D.C., and Thomas P. Fr ser, Morgan State College, Baltimo Md.) will have a program of particul interest to science and mathematics s pervisors, the morning of 27 Dec.

Science in General (X)

The annual *Academy Confere* (John A. Yarbrough, Meredith Colle Raleigh, N.C.,) composed of delega and other members of the 44 academ affiliated with the Association, will ho a day of sessions on 28 Dec., conclud with the annual dinner and president address by Yarbrough. An additio session devoted to a conference on jun academies is under consideration. T Academy Conference will sponsor t 12th annual Junior Scientists Assem (Keith C. Johnson, Woodrow Wils High School, Washington, D.C.) for lected high-school students, to be he at a convenient site, apart from the r of the meetings.

The *American Association of Scient Workers* (Robert J. Rutman, nation secretary, 6331 Ross St., Philadelph 44) is planning a one-day conference participation of women in science.

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The Properties of Certain Anion Exchange Resins and the Possibility of Using Them in the Medical and Food Industries.
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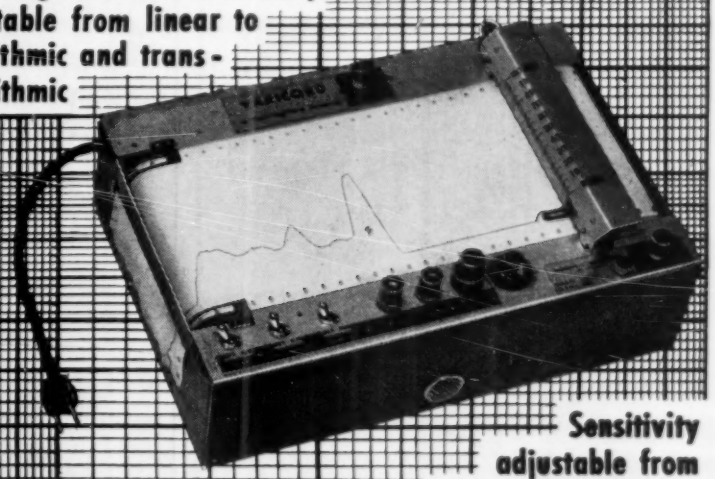

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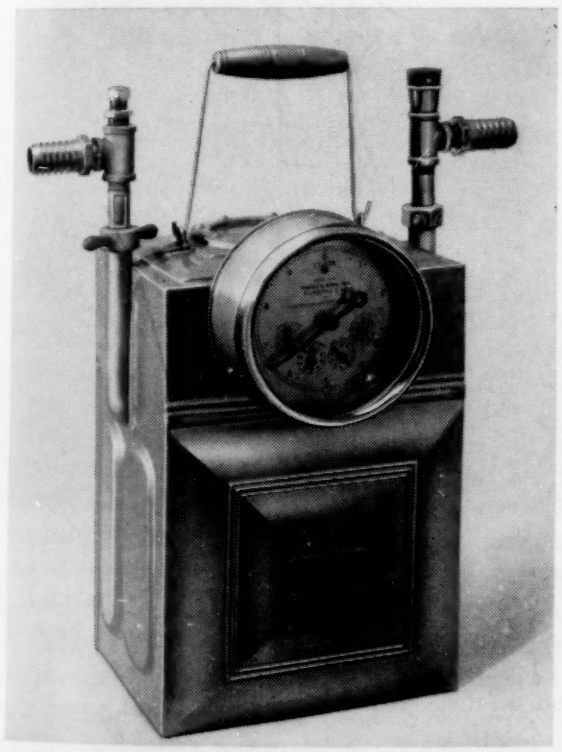

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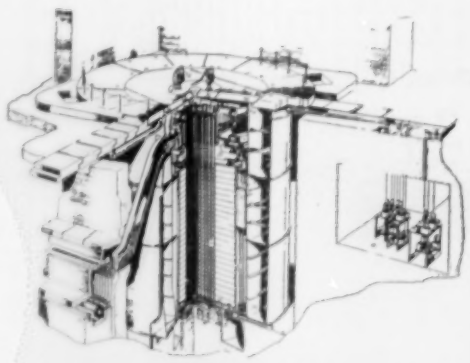

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The *American Geophysical Union* (Waldo E. Smith, AGU, Washington, D.C.) is planning a regional meeting and will cosponsor appropriate sessions, such as those on the IGY program.

The program of the annual national meeting of the *American Nature Study Society* (Stanley Mulaik, University of Utah) begins with a board meeting on 26 Dec. and includes, besides joint sessions with the science teaching societies, general sessions on 27 Dec. and the afternoon of 28 Dec. The annual dinner, followed by the annual showing of Kodachrome slides, will be held the evening of 29 Dec.; the joint field trip with the National Association of Biology Teachers will be held on 30 Dec.

The *Conference on Scientific Communication Problems* (George L. Seielstad, Applied Physics Laboratory, Johns Hopkins University, Silver Spring, Md.) now in its seventh year, will have six sessions, 28–30 Dec., devoted, respectively, to "Science in the News," "Science in Storage," "Science and the National Defense," "Science and "Three-Dimensional Presentations," "Science in Textbooks," and "Science in Translation."

Details of the annual *Conference on Scientific Manpower* (Thomas J. Mills, National Science Foundation) are not yet available. As in previous years, this program will be cosponsored by the *Engineering Manpower Commission, Scientific Manpower Commission, National Academy of Sciences–National Research Council,* and *National Science Foundation.*

The three sessions devoted to the *International Geophysical Year* (Hugh Odishaw, National Academy of Sciences, Washington, D.C.)—which, technically, concludes with the last day of the AAAS meeting—will outline the latest IGY findings (i) in the Arctic and Antarctic, (ii) on missiles and satellites, and (iii) in meteorology and oceanography.

The national meeting of *Sigma Delta Epsilon,* graduate women's science fraternity (Virginia Lee Blackford, Washington, D.C.), begins with a business meeting on 27 Dec. and includes the annual dinner and grand chapter meeting on 29 Dec. and a luncheon for all women in science on 30 Dec. A headquarters room will be maintained throughout the meeting period.

At least one of the annual addresses of the *Society of the Sigma Xi* (Thomas T. Holme, Yale University) and of the *Scientific Research Society of America* (Donald B. Prentice, Yale University) and the award of the William Procter prize are scheduled for the evening of 29 Dec., following the 59th annual convention of the Society of the Sigma Xi, the annual convention of RESA, and their joint luncheon.

The 19th annual lecture of the *United Chapters of Phi Beta Kappa* (Carl Billman, Phi Beta Kappa, Washington, D.C.) is scheduled for the evening of 27 Dec.

The *Washington Academy of Sciences,* which has as affiliates some 30 local scientific societies and local branches of national organizations, will have a special December meeting with the AAAS (George W. Irving, ARS, U.S. Department of Agriculture, Washington, D.C.).

Call for Papers by AAAS Sections

Eight sections of the Association will arrange sessions for contributed papers at the Washington meeting. The secretaries or program chairmen to whom titles and abstracts should be sent, *not later than 30 September,* follow:

C–Chemistry. F. O. Rice, Department of Chemistry, Catholic University of America, Washington, D.C.

E–Geology and Geography. Both geology and geography, cosponsored respectively by the Geological Society of America and the Association of American Geographers, Middle Atlantic Division: Frank C. Whitmore, Jr., U.S. Geological Survey, Washington 25, D.C.

F–Zoological Sciences (if outside the scope of the American Society of Zoologists and Society of Systematic Zoology, which are meeting with the AAAS). Karl M. Wilbur, Department of Zoology, Duke University, Durham, N.C.

G–Botanical Sciences. Barry Commoner, Henry Shaw School of Botany, Washington University, St. Louis 5, Mo.

K–Social and Economic Sciences. Donald P. Ray, Hall of Government, George Washington University, Washington 6, D.C.

L–History and Philosophy of Science. John W. Streeter, Franklin Institute, Philadelphia 3, Pa.

Np–Pharmacy. John E. Christian, School of Pharmacy, Purdue University, Lafayette, Ind.

O–Education. Herbert A. Smith, 2 Bailey, School of Education, University of Kansas, Lawrence.

Although the deadline is 30 Sept. for most sections, and subsequently the AAAS office, would be glad to receive titles in advance of this date.

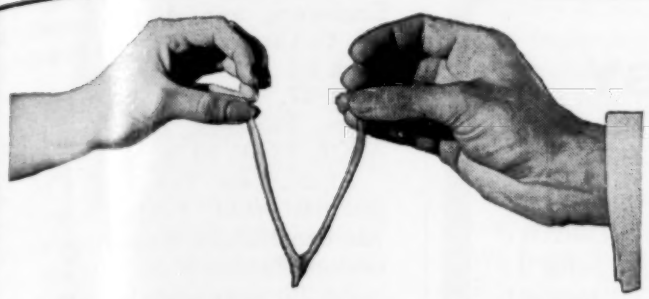
Raymond L. Taylor
Associate Administrative Secretary

Forthcoming Events

June

23–24. Unstable Chemical Species Symp., Los Angeles, Calif. (Director of Advanced Studies, Air Force Office of Scientific Research, P. O. Box 2035, Pasadena, Calif.)

23–25. American Soc. of Heating and Air-Conditioning Engineers, semiannual, Minneapolis, Minn. (A. V. Hutchinson, ASHAE, 62 Worth St., New York 13.)



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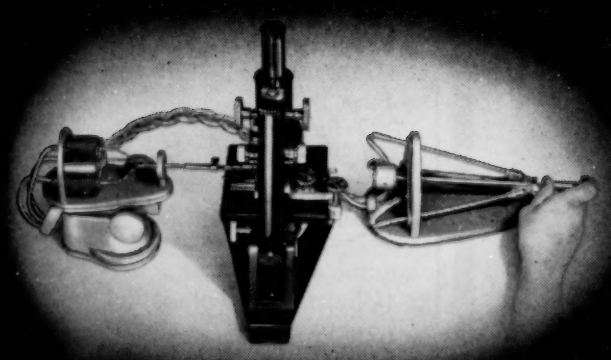

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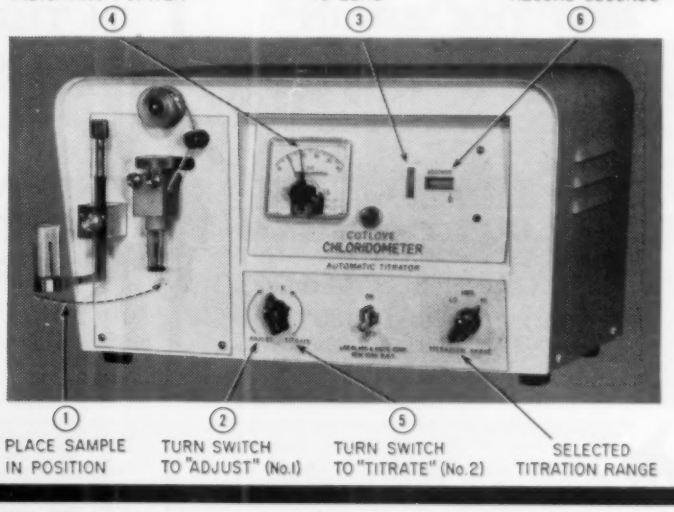

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edited by Sanford L. Palay

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23–25. American Soc. of Refrigerating Engineers, annual, Minneapolis, Minn. (R. C. Cross, ASRE, 234 Fifth Ave., New York 1.)

23–27. American Soc. of Civil Engineers, Portland, Ore. (W. H. Wisely, ASCE, 33 W. 39 St., New York 18.)

23–28. Low Temperature Physics, internatl. conf., Leiden, Netherlands. (W. van den Handel, Kamerlingh Onnes Laboratory, Leiden.)

24–26. Carcinogenesis: Mechanisms of Action, Ciba Foundation symp. (by invitation), London, England. (G. E. Wolstenholme, 41 Portland Pl., London W.1.)

24–27. American Home Economics Assoc., annual, Philadelphia, Pa. (Miss V. Horton, AHEA, 1600 20 St., NW, Washington 9.)

25–28. American Assoc. of Physics Teachers, Boulder, Colo. (F. Verbrugge, School of Physics, Univ. of Minnesota, Minneapolis.)

25–1. International Soc. of Urology, 11th, Stockholm, Sweden. (G. Giertz, Karolinska Sjukhuset, Stockholm C.)

29–2. American Astronomical Soc., Madison, Wis. (J. A. Hynek, Smithsonian Astrophysical Observatory, 60 Garden St., Cambridge 38, Mass.)

29–4. National Education Assoc., Cleveland, Ohio. (W. G. Carr, NEA, 1201 16 St., NW, Washington 6.)

30–5. High Energy Nuclear Physics Conf., annual (by invitation), Geneva, Switzerland. (CERN, Geneva 23.)

July

4–6. Astronomical League, Ithaca, N.Y. (Miss W. A. Cherup, 4 Klopfer St., Mt. Lebanon, Pittsburgh 9, Pa.)

6–12. Cancer Cong., 7th intern., London, England. (H. F. Dorn, National Institutes of Health, Bethesda 14, Md.)

6–12. Research and Development Engineering Seminar, 2nd annual, University Park, Pa. (Extension Conference Center, Pennsylvania State Univ., University Park.)

7–9. Exchange of Knowledge in a Divided World, Chicago, Ill. (H. W. Wing, Graduate Library School, Univ. of Chicago, Chicago 37).

7–11. Technical and Industrial Communications Inst., Fort Collins, Colo. (Chairman, Dept. of English and Modern Languages, Colorado State Univ., Fort Collins.)

7–12. Nuclear Physics, intern. conf., IUPAP, Paris, France. (C.I.P.N., Institut du Radium, II, rue Pierre Curie, Paris 5e.)

8–11. Institute of the Aeronautical Sciences, summer, Los Angeles, Calif. (S. Johnston, IAS, 2 E. 64 St., New York 21.)

9–15. Zoological Nomenclature Colloquium, London, England. (F. Hemming, 28 Park Village East, Regent's Park, London, N.W.1.)

10–14. Research Methods in Soil Zoology, colloquium, Harpenden, Hertfordshire, England. (P. W. Murphy, Rothamsted Experimental Station, Harpenden.)

15–22. Association Française pour l'Avancement des Sciences, 77th congr., Namur, Belgium. (AFAS, 28, rue Serpente, Paris VIe, France.)

(See issue of 16 May for comprehensive list.)

Letters

Legibility

The current intensified effort to make ...gn technical literature more acces... ...e raises questions about the legibility ...e translations scientists are expected ...eview and ways in which such defi... ...ies as occur in this respect can be ...ected. Scientists must do enough ...ding as it is without the additional ...den of having to read material that ...s better designed to increase eye... ...n than to impart information.

...e copies of translations which have ...e to our attention leave much to be ...ed. Many of the original translations ...e poorly typed—letters were faded or ...dged, and so on. Some reproductions ... been negatives—that is, white type ... black background—making for very ...icult reading. In a number of cases ...ctions in size of type and in spacing ...ween words and lines have com...nded the illegibilities and compacted ... text beyond acceptable minimum ...ndards.

...Such conditions undoubtedly contrib... ...to eyestrain, and thus to an increased ...in on our energies—and perhaps even ... build-up of psychological resistance ...he reading matter as a whole.

...Since requirements for effective scien... ... work undoubtedly encompass the ...l-being of the scientists themselves, ...suggest that information on standards ...summarized and disseminated for the ...ress purpose of promoting necessary ...provements in the materials we have ...read. (We recognize, of course, that ...er conditions may contribute to eye...in, such as poor lighting or improp... ...designed fixtures or furniture. Here, ... ample information is available on ...rable standards.) To that end we ...pose the appointment of an AAAS ...mittee to (i) collect and report on ...nically established legibility stand... ...s for reading matter; (ii) determine ... extent to which such standards are ...g met by translation services (public ...private), and (iii) work with such ...ices toward meeting standards where ... are not now being met. The follow... ...illustrates how standards can be for...lated. Maximum acceptable number ...lines per (vertical) inch may be taken ...10. Maximum number of characters ...ters, punctuation marks, and so on, ... word spaces) per line may be 60, ...n 25 to 50 an ideal range. Incidentally, ... American Council of Learned Socie... ...reported on a study on this general ...ject in a 207-page "Manual on Meth... ...of Reproducing Research Materials," ... Robert C. Binkley and others (Ed... ...rds, Ann Arbor, Mich.), in 1936.

...One objection that may be raised to ...er standards (one physicist of our ...uaintance did raise it) is that the cost of reproducing translations might be materially increased. Probably so, at least in the beginning. However, the benefits to the individuals and their work should be well worth the higher costs, if any. And in any event, technical ingenuity can surely be counted upon to bring down costs if the incentives to do so become strong enough.

We hope this letter will arouse discussion leading to positive action.

BERNARD FRANK
ROBERT T. HALL

Forest Service,
U.S. Department of Agriculture

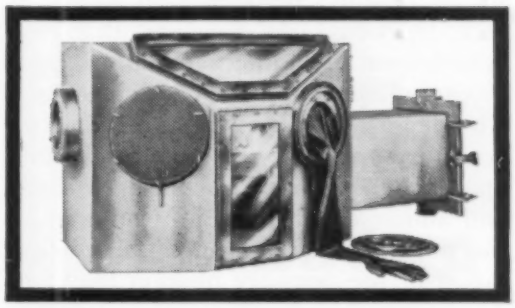
Blood-Group Nomenclature

The undersigned object to the report in the *Journal of the American Medical Association* for 31 August 1957 on "Medicolegal applications of blood grouping tests." In our judgment this report is a highly biased document, and certain of us have already expressed contrary opinions during the course of the report's formulation, without much effect. The Subcommittee on Medicolegal Problems responsible for this report consisted of four members all of whom are from the United States and two of whom were the chief protagonists for one of the nomenclatures under dispute. Therefore we, the undersigned, do not intend to abide by the recommendations of the report, and we shall continue to use the C-D-E nomenclature until such time as a properly representative international body arrives at a definite nomenclature.

FRED H. ALLEN, JR., SAM M. BEISER, WILLIAM C. BOYD, IVAN W. BROWN, JR., RUGGERO CEPPELLINI, HUGH CHAPLIN, JR., BRUCE CHOWN, WILLIAM H. CROSBY, WILLIAM DAMESHEK, I. DAVIDSOHN LOUIS K. DIAMOND, L. C. DUNN, STANLEY M. GARN, ELOISE R. GIBLETT, T. J. GREENWALT, MORTON GROVE-RASMUSSEN, HAROLD H. GUNSON, SOL HABERMAN, J. M. HILL, CALDERON HOWE, ELVIN A. KABAT, JULIUS R. KREVANS, PHILIP LEVINE, CHRICHTON MCNEILL, JAMES F. MOHN, SIDNEY RAFFEL, ALAN RICHARDSON-JONES, RICHARD E. ROSENFIELD, JOHN B. ROSS, JOHN SCUDDER, ARTHUR G. STEINBERG, PHILIP STURGEON, MAXWELL M. WINTROBE

The report of the Subcommittee on Medicolegal Problems, published in the *Journal of the American Medical Association,* contains a recommendation on Rh nomenclature that can hardly be conceived as a restriction on the liberty of the signers of the protest, or of anyone else active in the field, to use whatever terminology they choose. The desirabil-

for work in a controlled atmosphere



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ity of a *uniform* nomenclature appears to be a matter of common recognition; to quote from the summary and conclusions of the report: "Of the two available systems the Committee favors the Rh-Hr over the C-D-E for what it considers strong reasons. It recognized faults in both systems and suggests that the achievement of an internationally acceptable terminology is a desirable objective." The report contains a long section on "contrary opinion on nomenclature" (pages 2037–2039), recognizing a sharp and almost equal division of opinion on this matter and attempting a fair presentation of the contrary opinion that had come to the attention of the subcommittee. This diversity of opinion was further noted in the "summary and conclusions," where the recommendation is clearly identified as an "interim" one, to apply "unless and until some other convention can be agreed upon."

Perhaps the only conclusion that can be stated at present is that this issue will remain unsolved until "a properly representative international body arrives at a definite nomenclature." The virtually identical phrasing of the protest and the report itself in this connection (". . . suggests that the achievement of an internationally acceptable terminology is a desirable objective") may indicate a greater degree of concordance of opinion on the main issue than has previously been evident. If the report, and the protest it evoked, serve to point compellingly to the desirability of an acceptable solution to this issue, a useful service will have been performed.

COMMITTEE ON MEDICOLEGAL PROBLEMS
AMERICAN MEDICAL ASSOCIATION
Chicago, Illinois

Editor's note: The report referred to was prepared by a subcommittee consisting of A. S. Wiener, Ray D. O[illegible], Clyde Stormont, and Irving B. We[illegible]. It contains the following recommendation, under the heading "Summary and conclusions":

> Because the use of two systems of nomenclature for the Rh-Hr system leads to confusion and misunderstanding, the Committee on Medicolegal Problems of the American Medical Association recommends the adoption of a single uniform system for medicolegal reports. Of the two available systems, the Committee favors the Rh-Hr over the C-D-E for what it considers strong reasons. It recognizes faults in both systems, and suggests that the achievement of an internationally acceptable terminology is a desirable objective. In the interim, it is recommended that, unless and until some other convention can be agreed upon, the original Rh-Hr notations be kept as the standard and sole nomenclature for preparing improved medicolegal reports on Rh types.

For those who are uninformed about the long-standing controversy over the Rh nomenclature, it may be pointed out that the Rh-Hr nomenclature, developed and elaborated by A. S. Wiener, has priority in time and is generally favored by workers who regard the varieties of the antigens on human red blood cells as being determined by members of a multiple allelic series of genes. The alternative nomenclature, deriving from R. A. Fisher and R. R. Race, assumes a pseudoallelic relation between three closely linked genetic loci, C-D-E. This nomenclature, which to some extent is used in the United States, is used very widely, not exclusively, in Great Britain and Europe, where it is generally regarded as being considerably simpler to use in teaching the complexities of Rh inheritance. Repeated efforts have been made to arrive at a universally accepted nomenclature; but in the absence of certainty about the genetic realities of the situation, no compromise has been reached.

Obviously, the use of some standard and sole nomenclature would be desirable. On the other hand, the imposition of such a standard by an American group representing only one side of the controversy can serve only to sharpen international divisions of practice and opinion.—BENTLEY GLASS

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VENOMS

Edited by: **Eleanor E. Buckley,** Medical Department, Wyeth Laboratories; and **Nandor Porges,** Eastern Regional Research Laboratory of the U.S. Department of Agriculture, Philadelphia, Pennsylvania.

6 x 9 inches, 480 pages, 113 illustrations, index, clothbound, 1956. Price $9.50. AAAS Members' prepaid order price $8.25.

A symposium volume of the American Association for the Advancement of Science.

The more than sixty scientific papers included in this volume were presented at the first International Conference on Venoms during the AAAS Meeting in Berkeley, California. The authorship spans the globe, and the coverage of all aspects of the problem is equally comprehensive.

E. R. Trethewie of Australia reports experimental studies on certain pharmacological antagonists used in an effort to prolong life, providing more time for therapeutic measures. B. W. Halstead of the College of Medical Evangelists in California covers present knowledge on poisonous fishes. H. A. Reid of Malaya describes clinical effects of the bite of the sea snake (Enhydrina schistosa) in three fatal cases. Giovanni Favilli of the University of Bologna, Italy, discusses spreading factors in animal parasites and venoms, and some properties of hyaluronidase. The last subject is also covered by Paul Boquet, of the Institut Pasteur, in Paris. B. R. Criley and associates, of the Wyeth Laboratories, Marietta, Pennsylvania, describe the development and standardization of a multivalent refined antivenom for the family Crotalidae. The final article by H. L. Keegan of the U.S. Army Medical Corps presents an invaluable list of all known antivenins available throughout the world for all types of poisonous bites, with information on producers, sources, indications, dosages, and other details. The random selection is only a small sample of the wealth of valuable material by outstanding world authorities.

This book covers: poisonous fishes and marine organisms, many species of venomous snakes, the Gila monster, toads, scorpions, spiders, caterpillars, wasps and other venom-bearing insects; hyaluronidase-like substances and other spreading factors in venoms; various chemical components of venoms, coagulant and anticoagulant factors, antigenic principles; various experimental and suggested clinical uses of venoms; clinical considerations such as mortality rates in various localities throughout the world; and treatment of many kinds of envenomation (by snakes, scorpions, spiders and other organisms). Included are new developments in serotherapy and types of supplementary medication (as cortisone, ACTH, antihistamines). The dangers of refrigeration for treatment of envenomation are discussed.

Physicians, pharmacologists, chemists, and zoologists will all find this volume an invaluable reference.

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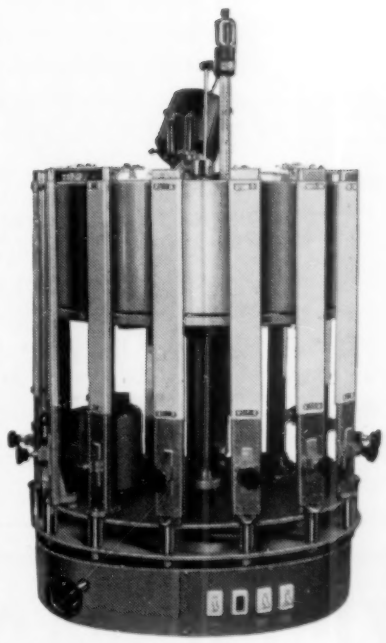

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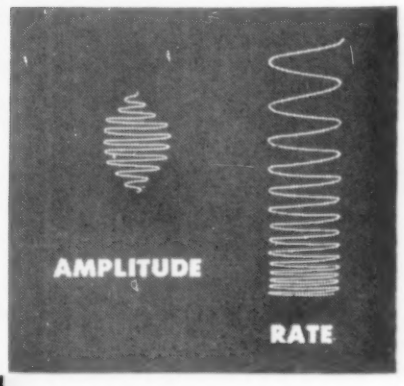

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